

DOCUMENT RESUME

ED 270 570

CE 044 422

TITLE Roof Framing. Building Trades. Block V.
INSTITUTION Texas A and M Univ., College Station. Vocational Instructional Services.
SPONS AGENCY Texas Education Agency, Austin. Dept. of Occupational Education and Technology.
PUB DATE 85
NOTE 171p.; For curricula on foundations, floor framing, wall framing, and interior trim, see ED 239 104, ED 256 954-955, and CE 044 423.
AVAILABLE FROM Vocational Instructional Services, Texas A&M University, F.E. Box 182, College Station, TX 77843 (Order #05405--\$8.70).
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Behavioral Objectives; *Building Trades; *Carpentry; Construction (Process); Job Skills; Learning Activities; Lesson Plans; Postsecondary Education; *Roofing; Secondary Education; Student Evaluation; *Trade and Industrial Education

ABSTRACT

This curriculum for roof framing provides instructional materials for 11 informational and manipulative lessons. A list of six references precedes the course materials. The instructor's plan for each informational lesson begins by providing this information: subject, aim, required teaching aids, required materials, references, and prerequisite experience of the learner. Components of the instructor's plan include preparation of the learner (motivation), presentation of information, application (teacher and student activities), verification and/or evaluation (final check on student's comprehension of materials presented), summary, and suggested reading for students. Information sheets and assignment sheets are provided as needed. The instructor's plan for a manipulative lesson begins with this information: task, aim, tools and equipment needed, materials needed, teaching aids, references, and checking standards. Components of the plan include preparation, presentation of the skills, application (practice by learner under close supervision), verification and/or evaluation, summary, and suggested reading for students. A job sheet and task sheets are provided. Topics covered include roof frame types (including terminology and layout), ceiling joists, gable roof framing, common rafters, gable end frames and extended roof rake, hip and valley rafters, and jack rafters. (YLB)

* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *

ED270570

BUILDING TRADES

BLOCK V

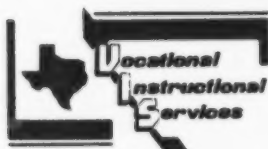
"ROOF FRAMING"

DEVELOPED

BY

VOCATIONAL INSTRUCTIONAL SERVICES

VOCATIONAL INDUSTRIAL EDUCATION



IN COOPERATION WITH

TEXAS EDUCATION AGENCY

OCCUPATIONAL EDUCATION AND TECHNOLOGY

VOCATIONAL INDUSTRIAL EDUCATION

(Printed 1985)

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)

- ☒ This document has been reproduced as received from the person or organization originating it.
- ☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS
MATERIAL IN MICROFICHE ONLY
HAS BEEN GRANTED BY

C. Roeder

TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC)."

Available From
VOCATIONAL INSTRUCTIONAL SERVICES
VOCATIONAL INDUSTRIAL EDUCATION
F. E. BOX 182
TEXAS A&M UNIVERSITY
COLLEGE STATION, TEXAS 77843

All Rights Reserved
by
Vocational Instructional Services
Texas A&M University

MAJOR BLOCK V - ROOF FRAMING

TABLE OF CONTENTS

V-A-1(I)	Roof Frame Types; Terminology-----	1
V-A-1(IS)	Roof Framing - Types, Terminology-----	9
V-A-1(AS)	Rafter Plain Layout-----	17
V-A-1(S)	Lay Out Roof Frame On Top Plates - Equal Pitch Gable Roof----	19
V-A-1(J)	Lay Out Roof Frame On Top Plates - Equal Pitch Gable Roof----	25
V-A-1(TS)	Lay Out And Mark Ceiling Joists On Top Plates-----	27
V-A-1a(TS)	Lay Out And Mark Common Rafters On Top Plates-----	29
V-A-1b(TS)	Lay Out And Mark Common Rafters On Ridge Board-----	31
V-A-2(I)	Ceiling Joists-----	33
V-A-1(IS)	Ceiling Joists-----	41
V-A-1(AS)	Ceiling Joist Plan Layout-----	47
V-A-2(S)	Lay Out Roof Frame On Top Plates - Equal Pitch Hip Roof-----	49
V-A-2(J)	Lay Out Roof Frame On Top Plates - Equal Pitch Hip Roof-----	55
V-A-2(TS)	Locate And Lay Out Ridge Board On Side Wall Plates-----	57
V-A-2a(TS)	Lay Out Common Rafters On Top Plates-----	59
V-A-2b(TS)	Lay Out Common Rafters On The Ridge Board-----	61
V-A-2c(TS)	Lay Out Hip Jack Rafters On Top Plates-----	63
V-A-2d(TS)	Lay Out Ceiling Joists On Top Plates-----	65
V-B-1(I)	Gable Roof Framing-----	67
V-B-1(IS)	Common Rafters-----	75
V-B-1(AS)	Sizing Common Rafters-----	83
V-B-1(S)	Lay Out And Cut Common Rafters-----	85
V-B-1(J)	Lay Out And Cut Common Rafters-----	91
V-B-1(TS)	Make Wood Straightedge Clamp (Optional)-----	93
V-B-1a(TS)	Select Common Rafter Material-----	95
V-B-1b(TS)	Lay Out Common Rafter-----	97
V-B-1c(TS)	Cut Common Rafter-----	99
V-C-1(I)	Gable End Frames And Extended Roof Rake-----	103
V-C-1(IS)	Gable End Frames-----	109
V-D-1(I)	Hip And Valley Rafters-----	113
V-D-1(IS)	Hip And Valley Rafters-----	123
V-D-1(AS)	Sizing Hip And Valley Rafters-----	129
V-D-1(S)	Lay Out And Cut Hip And Valley Rafters-----	131
V-D-1(J)	Lay Out And Cut Hip And Valley Rafters-----	139
V-D-1(TS)	Select Rafter Material - Hip/Valley Rafters-----	141
V-D-1a(TS)	Lay Out Hip/Valley Rafter Lengths-----	143
V-D-1b(TS)	Lay Out Hip/Valley Rafter Ridge Allowance And Side Cuts-----	145
V-D-1c(TS)	Lay Out Hip/Valley Rafter Bird's-Mouth-----	147
V-D-1d(TS)	Lay Out Hip/Valley Rafter Tails-----	149
V-D-1e(TS)	Cut Hip/Valley Rafter-----	151
V-D-2(I)	Jack Rafters-----	153
V-D-2(IS)	Jack Rafters-----	159
V-D-2(AS)	Jack Rafters-----	163
V-D-2(S)	Lay Out And Cut Hip And Valley Jack Rafters-----	165
V-D-2(J)	Lay Out And Cut Jack Rafters-----	171
V-D-2(TS)	Make Jack Rafter Pattern-----	173
V-D-2a(TS)	Lay Out Hip Jacks-----	175
V-D-2b(TS)	Lay Out Valley Jacks-----	178
V-D-2c(TS)	Lay Out Cripple Jacks-----	179
V-D-2d(TS)	Cut Jack Rafters-----	181

BLOCK V - ROOF FRAMING

REFERENCES

Durbahn, Walter E., and Sundberg, Elmer W., Fundamentals of Carpentry, American Technical Society, Chicago, IL 60637

Feirer, John L., and Hutchings, Gilbert R., Guide To Residential Construction, Bennett Publishing Company, Peoria, IL 61615

Huth, Mark, Introduction To Construction, Delmar Publishers, Inc., 50 Wold Road, Albany, NY 12205

Jones, Raymond, P., and Ball, John E., Framing, Sheathing And Insulation, Delmar Publishers, Inc., 50 Wolf Road, Albany, NY 12205

*Wagner, Willis H., Modern Carpentry, The Goodheart-Willcox Co., Inc., South Holland, IL 60473

Booklet, The Speed Square, Swanson Tool Company, Inc., P.O. Box 434, Oak Lawn, IL 60453

*State Adopted Text - V.I.E. Building Trades Construction Trades

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

V-A-1(I)

SUBJECT: Roof Frame Types; Terminology

AIM: The student will be able to properly identify different styles of roofs in current conventional home construction. The student will further be able to identify roof components and areas thereof applying proper terminology.

TEACHING AIDS: Information Sheet V-A-1(IS); Assignment Sheet V-A-1(AS)

MATERIALS: None

REFERENCES: Wagner, Willis H., Modern Carpentry, Unit 9
Jones, Raymond R., and Ball, John E., Framing Sheathing and Insulation, Units 14, 15, 16, 17, 18, 19

PREREQUISITE EXPERIENCE OF THE LEARNER: The student must have successfully completed previous lessons
I-A-1(I), Regular Pre-employment Building Trade
I-B-1(I), School Policies and Procedures
I-B-2(I), Shop Rules and Regulations
I-C-1(I), Shop Organization and Management
I-D-1(I), Personal and General Shop Safety
II-A-2(I), Blueprint Reading for Building Trades
III-B-1(I), Types of House Framing, Framing Components
The student must continue to display a sincere interest in learning the building trades.

I. PREPARATION (OF THE LEARNER - MOTIVATION)

The roof is the lid of a building or house. The primary function of the roof is to protect the house in all types of weather. The roof frame must be strong and rigid to support the roofing materials and resist the loads placed upon it by wind and weather.

Besides being practical, a roof should add to the attractiveness of a home or building. There are many styles and combinations of styles of roof. Most are associated with different countries and/or geographic-climate regions. The carpenter must understand roof types and terminology and be able to frame the more popular conventional styles.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING TOPICS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Roof Styles Pass out: V-A-1(IS)	1. Identify by name 2. Point out, show example, or illustrate 3. Define, describe, discuss
1. Basic	1. <u>Flat</u> -sits flat on top plates a. Rafters, joists one-and-the-same b. Sheathing, roofing applied to top of joists; ceiling applied to bottom

2. Shed or lean-to-slopes in one direction only
 - a. Slope may be slight or drastic
 - b. Rafters, joists may be the same; separate
 - c. Used in contemporary designs; additions to existing homes
 3. Gable-has two roof slopes
 - a. Slopes meet at a crest or ridge; sheds water to both sides
 - b. Forms a gable at each end
 - c. Most used roof style in home building
 4. Hip-has four roof slopes
 - a. Sheds water all four sides
 - b. May have a peak (square); may have a ridge (oblong)
 - c. Intersecting roof slopes form hips
2. Modified/Combined
1. Gambrel-similar to gable roof except:
 - a. Has two slopes each side of ridge
 - b. Usually lower slope is quite steep
 - c. Designed for extra attic space; rooms
 - d. Often includes dormers for light
 2. Mansard-similar to a hip roof except:
 - a. Has two slopes on each of four sides
 - b. Usually lower slopes are quite steep
 - c. Designed for attic or second floor
 - d. Includes dormers for light
 3. Gable and Valley
 - a. Gable style roof to accommodate other than square/rectangular floor plans
 - b. Require two or more intersecting ridges (in plan)
 - c. Creates valleys where roof slopes intersect
 4. Hip and Valley-similar to gable and valley using the hip style roof
 5. Gable and Shed-combination often used when an addition is added to a main roof
 6. Dutch Hip-style combines Hip and Gable
 7. "A" Frame-drastic modification of gable
3. Engineered/Exotic
1. Ultra modern, contemporary styles
 2. Used mainly in memorials, public buildings
 3. Engineered; do not employ conventional roof framing techniques
 4. Styles include:
 - a. Domes
 - b. Cylindrical paraboloids
 - c. Hyperbolic paraboloids
- B. Purpose of Roof
1. Cover or lid for a building
 2. Protect the house in all types of weather

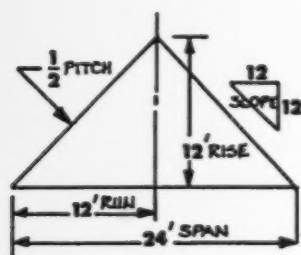
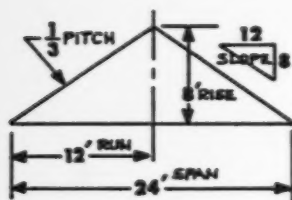
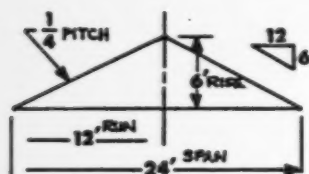
C. Methods of Roof Construction

- a. Resist wind, weather
- b. Support loads-snow, ice
- 3. Add to attractiveness of building or home
- 1. "Conventional"
 - a. Oldest, most common
 - b. Joists, rafters, other parts are laid out, cut, and fastened to the building one piece at a time
- 2. "Trussed"
 - a. Rafter trusses pre-constructed
 - b. Trusses delivered to site, set in place on top plates as unit
 - c. Units tied together form roof frame
- 3. "Plank and Beam"
 - a. Post and beam framework. Consists of:
 - 1) series of posts and beams
 - 2) strategically spaced
 - b. Heavy planks placed across beams form roof deck

D. Parts of Roof Frame

- 1. Ridge board-horizontal member that connects the upper end of the rafters
 - a. Serves as crest of roof frame
 - b. Generally runs with length of building
- 2. Rafters-inclined members of roof frame
 - a. Main roof framing member(s)
 - b. Serves same purpose as joists in floor frame; studs in wall frame
 - c. Usually spaced 16" or 24" O.C.
 - d. Size varies depending on length, spacing, type materials, and loads
 - e. Several kinds
- 3. Common rafters-main type rafter
 - a. Runs at right angles from ridge to plate
 - b. Used as basis for layout of other rafters
- 4. Hip rafters
 - a. Run diagonally from outside corner of plates to ridge board
 - b. Connect two intersecting roof slopes to form a hip
- 5. Valley rafters
 - a. Run diagonally from inside corners of plate
 - b. Connect two intersecting roof slopes to form a valley
- 6. Jack rafters are foreshortened rafters. (3) kinds:
 - a. Hip Jacks-extend from plates to hip rafters
 - b. Valley Jacks-extend from ridge board to valley rafters

E. Rafter Layout Terms



F. Roof Framing Plans

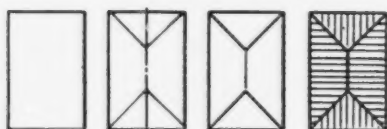
- c. Cripple Jacks-extend from hip rafters to valley rafter
 7. Ceiling Joists-horizontal members that rest on the wall plates
 - a. Form the bottom of the roof frame
 - b. Generally run parallel with the rafters
 - c. Serve as tension members to resist outward thrust of rafters
 - d. Carry finished ceiling
 8. Collar beam-horizontal tie beam
 - a. Connects two opposing rafters considerably above the plates
 - b. Placed on approximately every third set of rafters for added bracing
 1. Span-building width; measured out-to-out of exterior walls top plates
 2. Run-one-half of span on roofs having equal pitch
 3. Measuring line-imaginary line running from top, outside edge of wall plate to the center of the ridge
 4. Rise-vertical distance from top of wall plate to upper end of measuring line
 5. Cut of the roof-angle which roof surface makes with horizontal plane
- Note: Cut of the roof is expressed two ways: slope; pitch. (Show examples)
6. Slope-expressed as a ratio, "rise to run"
 - a. Rise given in inches is variable
 - b. Run given in the unit 12(foot); constant
 7. Pitch-expressed as a fraction, "rise over span"
 - a. Rise given in inches is variable
 - b. Run given in the unit 12(foot) constant
 8. Plumb line/cut -any vertical line or cut on the rafter with it in its proper position
 9. Level line/cut -any horizontal line or cut with the rafter in its proper position
 10. Bird's mouth-a notch cut out on the bottom of the rafter so rafter will sit solidly on the plate
 11. Overhang-that portion of the rafter which extends beyond the building line
 12. Rafter tail-overhang of rafter
 1. Are usually included among architect's working drawings
 2. Are more of a framing diagram
 3. Helps carpenter determine what kinds of rafters and numbers necessary to frame a roof

1. Gable Roof



Frame plan for gable roof.

2. Hip Roof



Frame plan for hip roof.

3. Gable and Valley



Gable and valley roof frame plan.

Note: There are four types of roofs that generally concern carpenters: Gable, Hip, Gable and Valley, Hip and Valley

4. If no roof frame (rafter) plan exists, carpenter should make his own
 - a. Study plans; elevations
 - b. Determine roof type; rafter spacing

1. Layout building outline to scale
2. Determine direction rafters will run (generally across width of building)
3. Draw a center line at right angle to this direction. Centerline locates ridge board
4. Layout rafters/roof frame plan 90° to ridge
 - a. Start at one end; place 1st rafter flush on end building line
 - b. Maintain 16"-24" O.C. rafter spacing throughout building length
 - c. Place last rafter on opposite end building line
 - d. Allow last space to fall where it may

1. Lay out building outline to scale
2. Locate and draw center line lightly
3. Draw 45° angles bisecting corners to intersect at centerline

Note: These intersection points establish the length of the ridge board

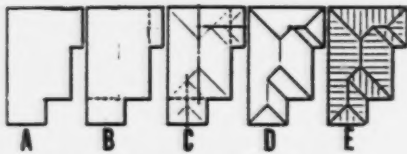
4. Draw ridge line and hip rafters
5. Layout common rafters along ridge board
 - a. Start at one end; place 1st rafter flush with end of ridge board
 - b. Maintain 16"-24" O.C. rafter spacing throughout ridge length
 - c. Place last rafters flush with opposite end of ridge board
 - d. Allow last space to fall where it may
6. Lay out common rafter each end of, in line with ridge board
7. Layout jack rafters along side; ends
 - a. Start at common rafters and work toward corners
 - b. Maintain 16"-24" spacing
 - c. Allow odd space to fall at the corner

1. Lay out building outline to scale
2. Locate and draw center lines lightly
 - a. Larger rectangle first
 - b. Smaller rectangle(s) second
3. Draw 45° angles from inside building corners to intersect at centerline
4. Draw in ridge lines; valley rafters
5. Determine rafter spacing and lay out roof/rafter plan as previous plans

II. PRESENTATION (CON'T)

V-A-1(I)

4. Hip and Valley



Hip and valley roof frame plan.

1. Layout building outline to scale (Fig. A)
2. Outline largest possible rectangle inside the building line (Fig. B)
3. Draw center lines for each rectangle formed inside the building outline (Fig. C)
4. Draw lines at 45° from each corner, inside and outside, to intersect at a center line (Fig. C)
Note: At theoretical corners of rectangle laid out in key point #2 above, project 45° angles to intersect two center lines. Length between centerlines is a hip rafter
5. Draw in all hip rafters, valley rafters, and ridge boards (Fig. D)
6. Determine rafter spacing and layout roof/rafter plan (Fig. E)

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS, OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

Instructor: Pass out Assignment Sheet VI-A-1(AS).

Discuss assignment with students.

Students: Complete assignment as per instructions.

Submit assignment to instructor for grade.

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

Recall/Completion:

1. The primary purpose of the roof is to protect the house in all types of weather.
2. The four basic roof styles are Flat, Gable, Shed, and Hip.
3. The most used style of roof in home building today is the Gable roof.
4. The Gable roof employs the use of common rafters only.
5. Two roof styles designed to gain additional space for attic room are the Gambrel and the Mansard.
6. A projection from the normal roof line to house a window is called a/an dormer.
7. Three methods of roof construction are conventional, trussed, and plank and beam.
8. The horizontal framing member that connects the upper end of rafters is referred to as the ridge board.
9. Ceiling joists act as tension members to resist outward thrust of rafters; carry finish ceiling.

10. Foreshortened rafters that run from the plates to the hip rafters are called hip jacks.
11. A notch cut in the bottom of a rafter so it may sit solidly on the plate is called a/an bird's mouth.
12. The width of a building from out-to-out of the plates is called its span.
13. An equal pitch gable roof with an 8'-0 rise and 12'-0 run has a 1/3 pitch.
14. That part of a rafter which forms the overhang on a roof is called the rafter tail.
15. The top cut of a common rafter to butt flush against the ridge board is referred to as a plumb cut.

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

The primary function of the roof is to protect the house in all types of weather. The roof frame must be strong and rigid to support the roofing materials and resist the loads placed on it by wind and weather.

Besides being practical, the roof should add to the attractiveness of the house. There are many styles and combinations of styles of roofs. Most are associated with different countries and/or geographic regions and developed slowly over years of design and use -- to be functional for that particular climate or region; utilizing available native building materials in that region; and reflecting cultural mores of its people.

Although the basic reasons for roof styles are not as prevalent today, styles still exist dictated most by public taste. The carpenter should be familiar with the many styles and possess a roof framing savvy that will enable him to perform most roof framing jobs.

There are four basic roof styles: Flat, Shed, Gable, and Hip; and an infinite number of variations and/or combinations of these roof styles. Of most concern to the carpenter are the Gable, Hip, Gable and Valley, and Hip and Valley. The shed, or lean-to, is one-half of a gable roof.

These roof frames generally run across the building width. That is, the ceiling joists and rafters span the narrowest part of the building. This width, out-to-out of the rafter plates, is referred to as the building span and plays an important role in rafter layout.

Other terms to be familiar with are:

Run - one-half of the span (on equal pitch roofs)

Rise - vertical distance from rafter plate to measuring line on rafter

Pitch - a ratio of the rise to the span given as a common fraction

Slope - a ratio of rise to run given as inches in 12

Plumb line/cut - any vertical line or cut with the rafter in its proper position

Level line/cut - any level line or cut with the rafter in its proper position

Bird's mouth - a notch cut on the bottom of the rafter so rafter will sit solidly on plates.

SUGGESTED READING FOR STUDENTS:

Modern Carpentry, pp. 152-175

THE NEXT LESSON IS: V-A-2(I) "Ceiling Joists"

INFORMATION SHEET
ON
ROOF FRAMING

V-A-1 (IS)

SUBJECT: Roof Framing - Types, Terminology

INTRODUCTORY
INFORMATION:

The roof is virtually the lid of a building or home. The primary function of the roof is to protect the house in all types of weather. The roof frame must be strong enough to support the roofing materials placed upon it, and to resist the loads inflicted by wind and weather. The roof frame may also serve to tie and brace the upper wall frames.

Aside from being practical, the roof should add to the attractiveness of the building or home. There are many styles and combinations of styles of roofs. Most are associated with different countries and/or geographic regions. These styles evolved over years and years of design and use -- to be functional for a particular climate or region; to utilize available (native) building materials in that region; and to reflect the cultural mores of the people of that region.

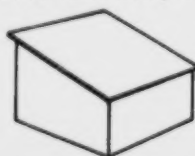
Although the basic reasons for a roof style are not as prevalent today, styles do still exist and are affected to some degree by the physical environment. However, with today's modern methods, materials, and processes, styles are dictated more by public demand. Today's carpenter must be familiar with various roof styles and especially those more popular roof styles used for light and/or home construction.

GENERAL INFORMATION:

The four basic styles of roof are flat; shed or lean-to; gable; and hip.



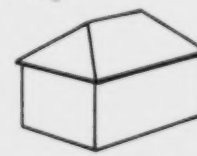
FLAT ROOF



SHED OR LEAN-TO-ROOF



GABLE ROOF



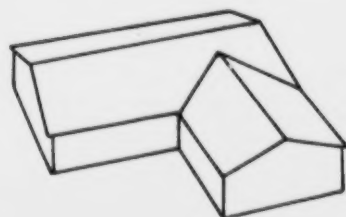
HIP ROOF

In flat roofs, the ceiling joists and the rafters are one-and-the-same. They are generally laid flat across top plates with sheathing and bituminous roof covering on top, insulation, and ceiling material on the bottom. Flat roofs may have a slight crown or slope to improve runoff.

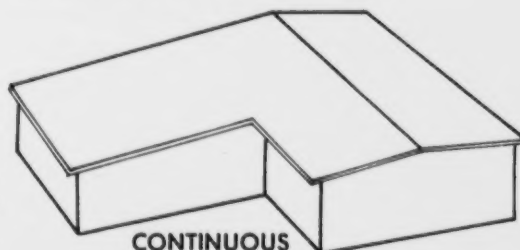
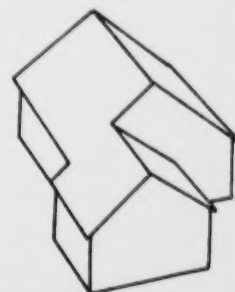
The shed or lean-to roof is the simplest type of pitched roof. It sheds water in one direction only. The slope or pitch may be slight or drastic. The ceiling may be sloped and attached to the underside of the rafters, or it may be flat and installed on separate ceiling joists. The shed type roof is versatile and may be used by itself or in combination with other roof styles.

The gable roof is probably the most common roof in home construction today. The gable roof consists of two sloping sides which meet at the top, or ridge, and form a gable at each end wall. There are countless variations of style in the gable roof.

The hip roof slopes at the ends of the building as well as the sides. These slopes create a hip line at their points of intersection - hence the name. The low appearance of this roofline, plus the fact that it does away with any siding above the eave line, minimizing maintenance, makes it a popular roof.

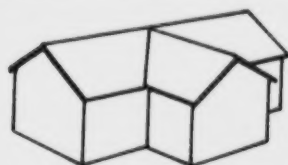


L-SHAPED GABLE ROOF

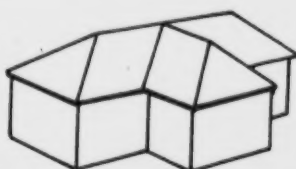
CONTINUOUS
LOW SLOPE GABLE

CONTINUOUS SLOPE GABLE

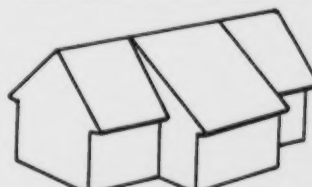
VARIATIONS OF THE GABLE ROOF



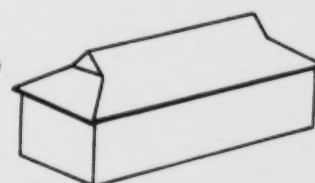
GABLE & VALLEY ROOF



HIP & VALLEY ROOF



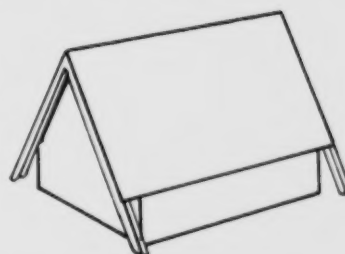
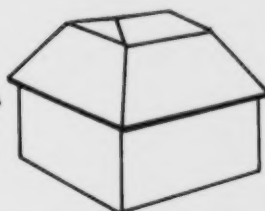
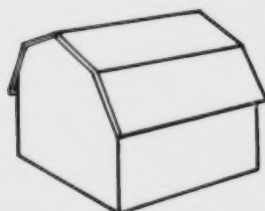
GABLE/LEAN-TO-ROOF



"DUTCH" HIP

COMBINATIONS OF ROOF STYLES

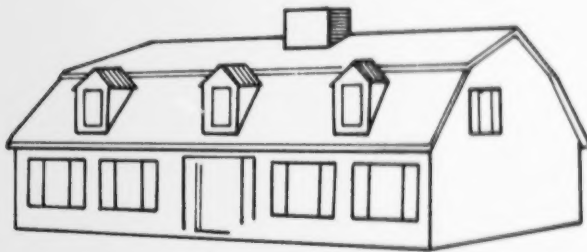
There are an infinite number of variations, combinations, and modifications of the four basic roof styles to suit most any floor plan, individual's taste, style, or decor. Above are just a few samples! Occasionally, through popular use, a modified roof type is recognized as a style of its own. Modified roofs recognized as a style are the Gambrel, the Mansard, the Dutch Hip, and more recently, the A-Frame.



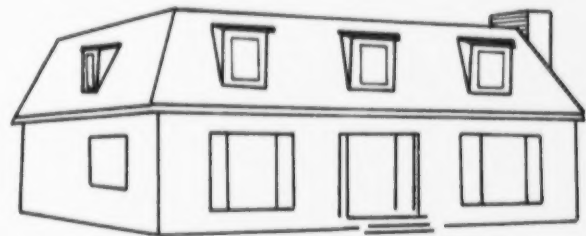
The Gambrel is a variation of the gable roof. Instead of having two slopes (one each side) that meet at a ridge, it has four slopes (two each side); the lower slope being quite steep. Partway up, a second, flatter slope continues toward a ridge in the center of the building. This roof style was designed to gain additional

space for attic or second floor rooms. Quite often, dormers are incorporated for windows and light. The Gambrel style was first used in the United States by German settlers in New York and Pennsylvania and is still popular today.

The Mansard roof is a variation of the Hip roof as the Gambrel is of the Gable. Instead of one slope each side, it has two. Again, the lower slopes are quite steep creating more attic space for additional room(s), and again, dormers are frequently incorporated for windows and light. The name was derived from its originator, architect Francois Mansart (1598-1666).



GAMBREL



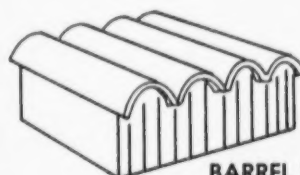
MANSARD

The A-Frame, a relatively recent popular roof style, is a dramatic modification of the Gable roof. It is difficult to determine exactly when; however, it is easy to determine why it is popular. It is modern! Probably the first in the modern era of roof styles, it appeals to that portion of the public taste. It is strong -- it is economical -- it is versatile! It can be adapted to a small cabin or a large building. It lends itself well in various surroundings and a variety of decors, and it looks good when combined with other roof types.

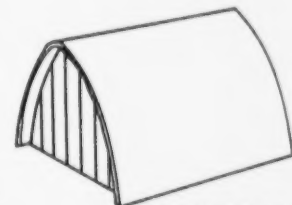
Ultra-modern roof styles have evolved in recent years. With advanced technology in construction procedures, materials, and processes these roofs do not employ conventional framing techniques and are referred to as engineered roofs. The student of building trades should be aware of them, and be able to identify many of them by name. Below are just a few!



FOLDED PLATE



BARREL VAULT

CYLINDRICAL
PARABOLOID

HYPERBOLIC PARABOLOID

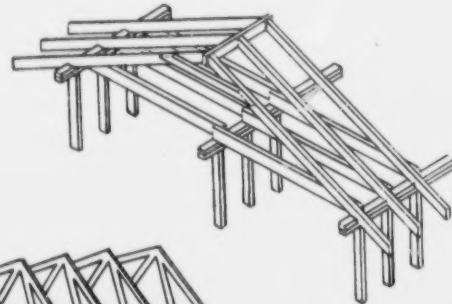


DOME

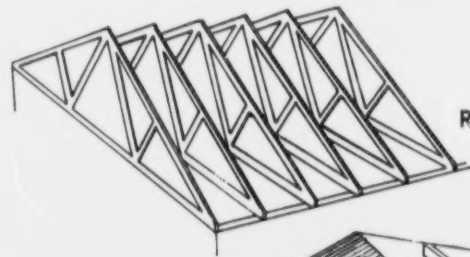
There are three methods of roof framing for light or home construction:

1. The oldest and most common method is "conventional framing" where the ceiling joists, rafters, and other parts are cut and assembled at the building site.
2. A second method becoming widely used, especially in mass production units, is "trussed framing". Roof trusses are pre-constructed off the building site, delivered to the site, and set in place.
3. The third method is "plank and beam" construction which generally consists of a series of parts and beams strategically spaced with heavy planks placed across the beams to form the roof deck.

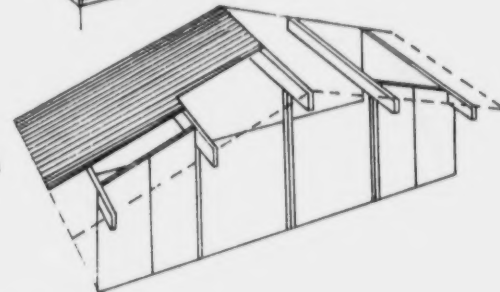
CONVENTIONAL
FRAMING



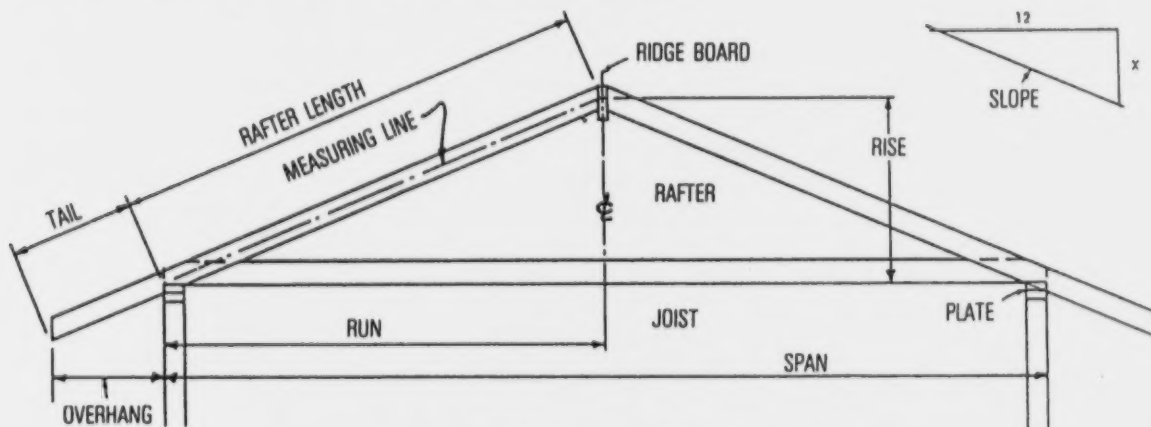
ROOF TRUSSES



POST AND BEAM
ROOF SYSTEM



Carpenters who construct roofs must not only be familiar with today's roof styles, but must understand roof design, roof terminology, and rafter layout to properly construct roof frames according to plans and specifications. The main parts of a roof frame are the ridge board, the rafters, and the ceiling joists.

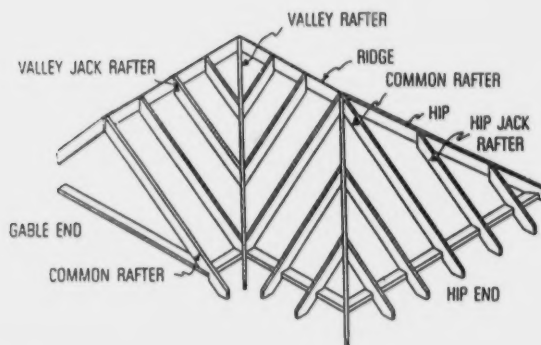


Basic terms and dimensions used in rafter layout.

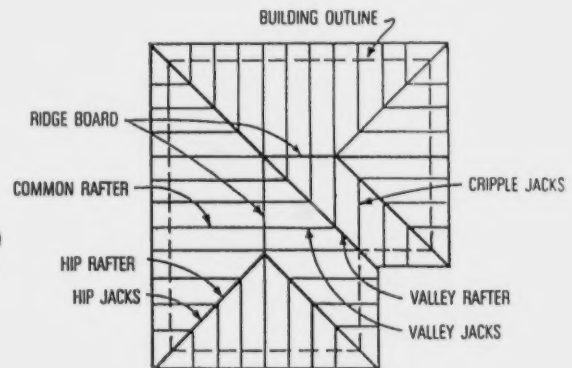
The ridge board is a horizontal piece that connects the upper ends of the rafters. It serves as the crest of the roof frame and generally runs with the length of the building.

Ceiling joists are horizontal members that rest on the wall plates to form the bottom of the roof frame. They generally run parallel with the rafters and serve as tension members to resist the outward thrust of the rafters and to carry the ceiling material.

The rafters are the inclined members of the roof frame. They serve the same purpose in the roof as joists in the floor and studs in the wall. Rafters are usually spaced 16" or 24" apart and vary in width depending on the length, spacing, and the type of roof covering used. Rafters often extend beyond the building line to form eaves to protect building walls. There are several kinds of rafters used in framing the different types of roofs:



HIP-AND-VALLEY ROOF



HIP RAFTER PLAN

Common rafters run at a right angle from the ridge to the plate. This rafter is one of the main structural supports of the roof. The common rafter is used as a basis for the layout of the other kinds of rafters.

Hip rafters extend diagonally from outside corners of the plates to the ridge board. Hip rafters connect two intersecting roof slopes to form a hip.

Valley rafters extend from inside corners of plates to the ridge board and connect two intersecting roof slopes to form a valley.

Jack rafters - foreshortened rafters - (3) kinds

Hip jacks - extend from plates to hip rafters

Valley jacks - extend from ridge board to valley rafters

Cripple jacks - extend from a hip rafter to a valley rafter

Rafter layout is based on the geometric principles of the right triangle. Other rafter/roof terms a carpenter should be familiar with are as follows:

Span - the width of the building measured from outside to outside of the exterior wall top plates and 90° to the plates.

Run - one-half the span on a roof have equal pitch.

Measuring line - an imaginary line running from the outside edge of the exterior wall plate to the center of the ridge.

Rise - vertical distance from the top of the wall plate to the upper end of the measuring line - the vertical distance a sloped roof rises to its horizontal run.

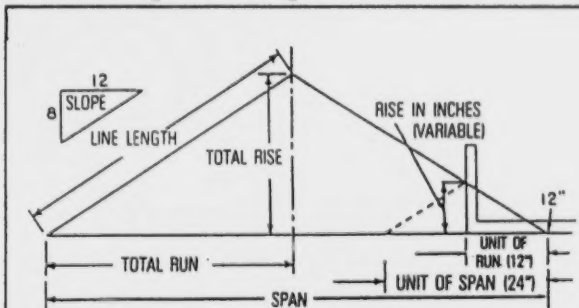
Cut of a roof - the angle which a roof surface makes with a horizontal plane.

Cut of a roof is expressed two ways: slope; pitch.

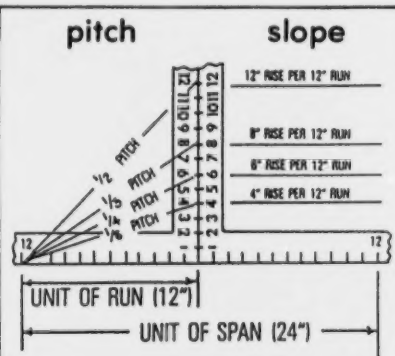
Slope - the rise of a roof to its run. Generally expressed as a ratio, inches rise per unit run (12), thusly: 6-12 (6" rise per 12" run).

Pitch - the rise of a roof to its span. Generally expressed as a fraction:

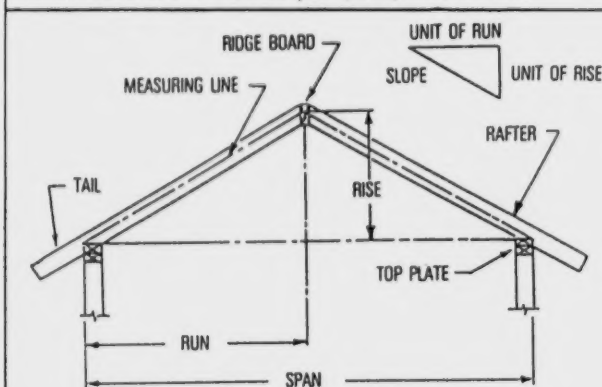
6' rise, 24' span = 1/4 pitch.



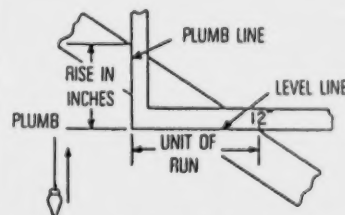
A comparison of total and unit terms. The unit run is always 12". Therefore the unit of span is always 24". The rise in inches is variable, depending on the pitch assigned to the roof. In the example shown here, there are 8" of rise per (foot) unit of run.



Two methods of expressing the cut of the roof.



Terms used in roof framing.



The framing square is used to lay out the plumb and level lines on a rafter. The plumb line is drawn along the tongue of the square and the level line along the body (sometimes called the blade).

Plumb line - any vertical line on the rafter when it is in its proper position.

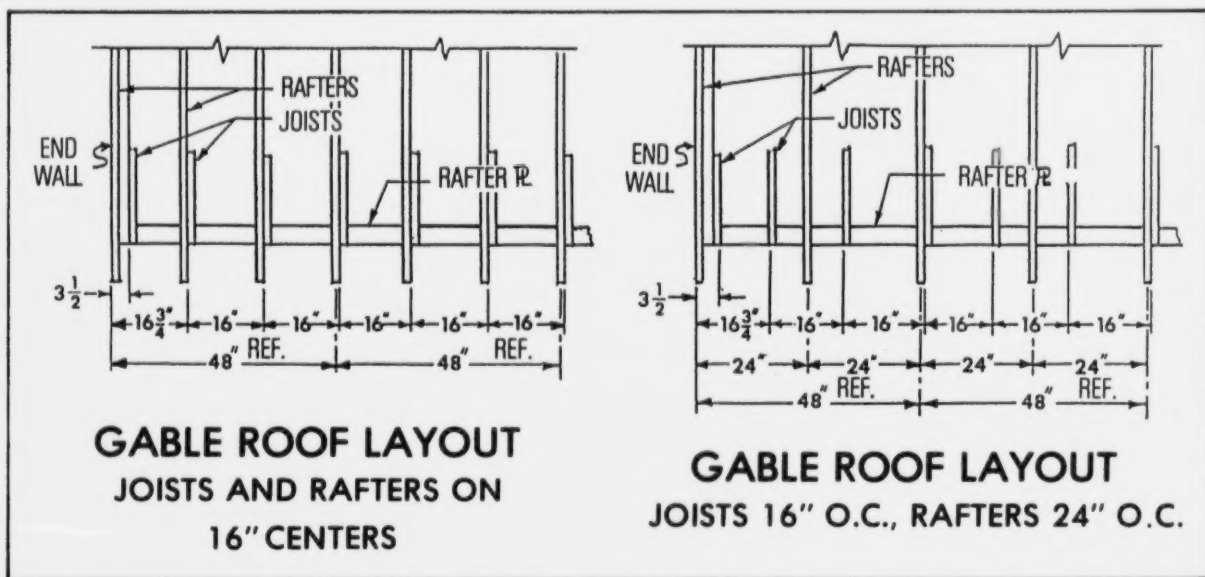
Level line - any horizontal line on the rafter when it is in its proper position.

Rafter tail - that part of a rafter which extends beyond the building line.

Overhang - that portion of the rafter which extends beyond the building line; the rafter tail.

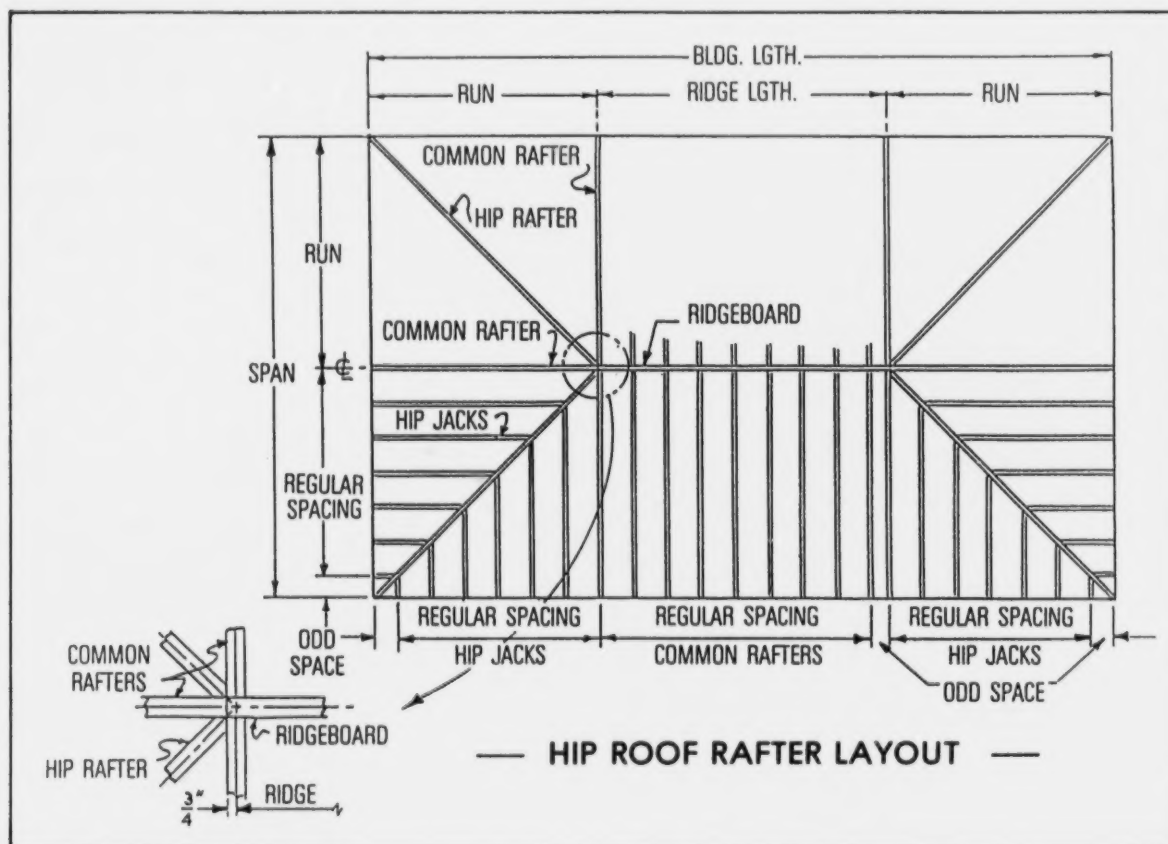
Bird's mouth - a cut out on the bottom side of the rafter so that the rafter will fit firmly and solidly on the rafter plate.

Layout of rafters and ceiling joists takes place on the top plates and must coordinate with each other. Layout for a gable roof starts at one end and continues across the length of the building. Place the first and last rafters flush with the outside of the end walls; maintain 16"-24" spacing; allow last space to fall where it may short of regular space.



Layout for a hip roof is just a little more complicated as follows:

1. Determine the length of the ridge board. Subtract two building runs from the building length and add the thickness of one rafter.



2. Locate the ridge board length on the side wall top plates. Measure from one end of the building, the length of one run minus $\frac{3}{4}$ ". Measure the ridge board length.
3. Lay out common rafters on side wall top plates. Start at marks locating one end of ridge board. Place first and last rafters flush with end of ridge board. Maintain 16"-24" spacing. Allow last space to fall where it may short of regular space.
4. Lay out common rafter centered on each end wall top plate.
5. Lay out hip jack rafters. Work from common rafters toward corners. Maintain 16"-24" spacing. Allow odd space to fall in corners.

ASSIGNMENT SHEET
IN
ROOF FRAMING

V-A-1 (AS)
KEY

SUBJECT: Rafter Plan Layout

AIM: The student will be able to lay out rafter plans for the types of roofs which are usually of most concern to the carpenter: Gable, Hip, Gable and Valley, Hip and Valley.

INTRODUCTORY
INFORMATION:

Carpenters must determine numbers and kinds of framing members necessary for framing a roof. A rafter plan may be included among the architect's working drawings. If not, the carpenter should make one, obtaining the necessary information from the architect's plans, elevations, and details.

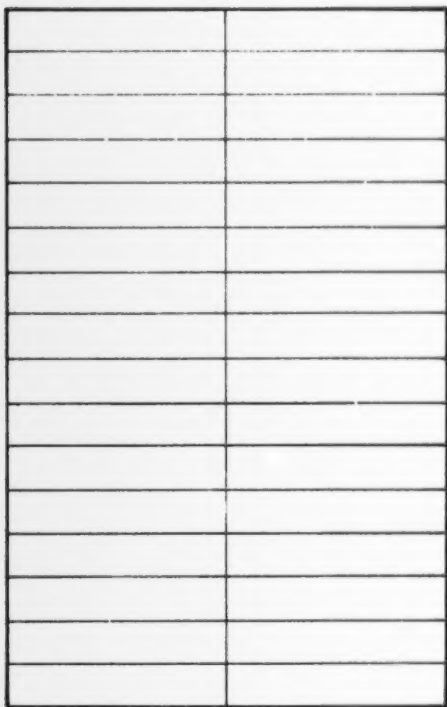
REFERENCES:

Information Sheet V-A-1 (IS), Roof Framing; Types, Terminology

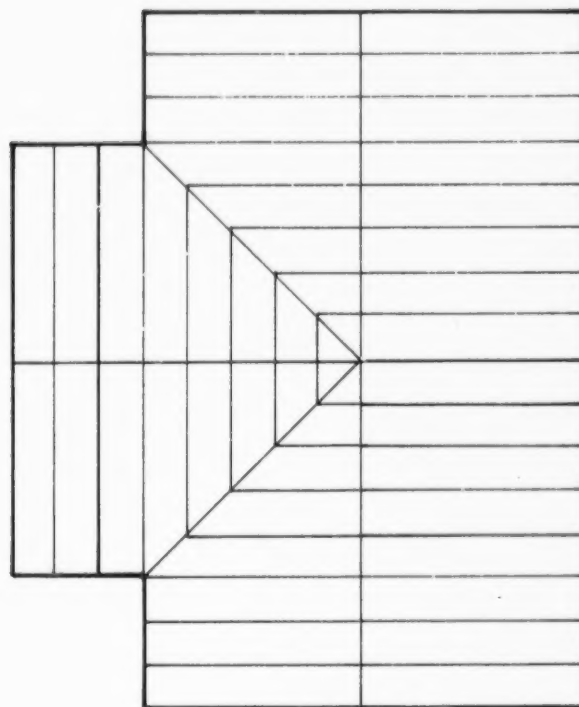
QUESTIONS OR PROBLEMS:

1. On the back of this sheet are four building outlines. On each outline lay out the rafter plan for the roof type indicated below each outline. Use $1/4" = 16"$ for rafter spacing.
2. On the gable roof assume all materials are 2 x 6's; each common rafter 12'-0" long. How many board feet are required for the rafters? 408
3. How many common rafters are in the hip roof? 14
4. How many common rafters are in the Gable and Valley roof? 33
5. If the big rectangle of the Hip and Valley roof were 24' x 40', the theoretical length of the ridge board would be 16.

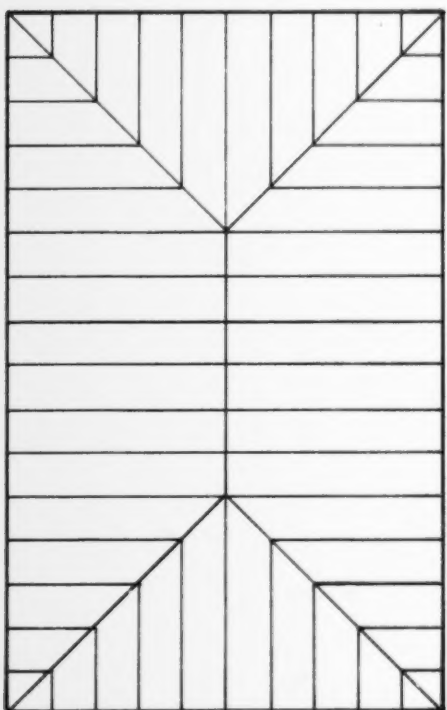
(SEE BACK OF SHEET FOR ROOF PLANS)



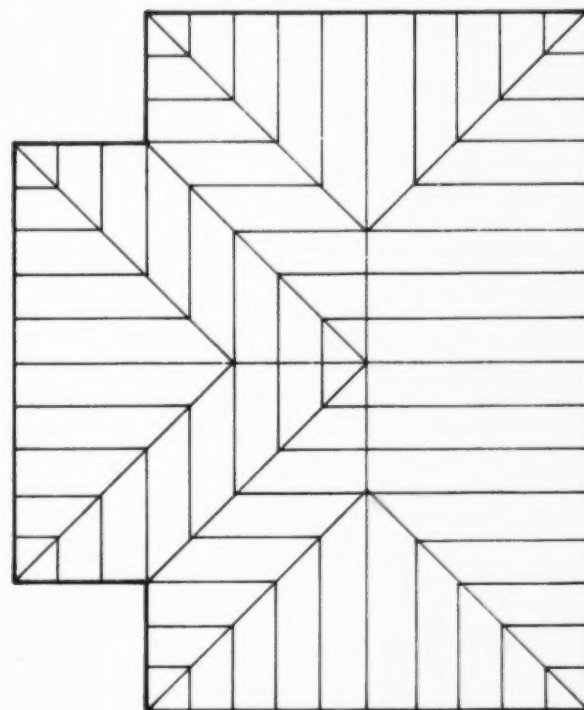
GABLE



GABLE AND VALLEY



HIP



HIP AND VALLEY

INSTRUCTOR'S PLAN
MANIPULATIVE LESSON

V-A-1(S)

TASK: Lay Out Roof Frame on Top Plates - Equal Pitch Gable Roof

AIM: The student will be able to properly, accurately, and methodically lay out joist, rafter, and gable end stud locations on the top plates of the building walls for a plain gable roof.

TOOLS AND EQUIPMENT: Framing square, 25' steel measuring tape, 3'-4' scaffolding

MATERIALS: Marking pen or pencil

TEACHING AIDS: Plans and specifications, Job & Task Sheets V-A-1

REFERENCES: Wagner, Willis H., Modern Carpentry, Units 7 and 8

CHECKING STANDARDS: 1. Joist direction, spacing; extra joist location, framing
2. Rafter spacing; alignment
3. Gable end stud location; spacing

I. PREPARATION (OF THE LEARNER - MOTIVATION)

In any construction, accurate lay out is of utmost importance. Without accurate layout a project is doomed from the beginning. This is especially so in the lay out for roof framing, where one piece is located from the previous piece. A rafter mislocated in the beginning may not show up out of place til near the end of rafter framing and would be costly to correct. It pays to be accurate and to double check your layout before you start framing.

II. PRESENTATION (OF THE SKILLS)

STEPS	KEY POINTS (THINGS TO REMEMBER TO DO OR SAY)
1. Study Plans, Specifications	1. Determine direction of joists 2. Determine type joists a. Single span b. Spliced; inline c. Lapped over load bearing partition 3. Verify joist spacing 4. Locate extra joists - special framing for ceiling opening 5. Determine rafter spacing 6. Determine gable end stud location and spacing 7. Become familiar with all layout dimensions
2. Set Up Scaffolds	1. To a convenient work height (3'-4') 2. For lay out on the top plates 3. To be solid and sturdy 4. Start at one end (left end) 5. Work across building length

3. Lay Out Ceiling Joists On 16" Center
 6. Move scaffolds as required; as lay out (all) progresses across building top plates
 1. On side wall top plates
 2. On intermediate wall plate as required
 3. One wall at-a-time
 4. Start at one end (left end) all lay out
 5. Work across length of building (left to right)
 6. Use framing square and pencil
- A. Lay Out First Joist
 1. Position framing square on top plate
 - a. Face up
 - b. Inside of body to far side of plate
 - c. Tongue across top of plate square
 2. Align 3 1/2" dimension, inside of body, with left end of plate (building line)
 3. Draw lines each side of tongue squared on plate
 4. Mark "J" between lines
- B. Lay Out Second Joist
 1. Slide framing square along top plate
 2. In direction of next joist (left to right)
 3. Align 16 3/4" dimension, inside of body, with end of plate (building line)
 4. Square tongue across plate and mark line each side
 5. Mark "J" between lines
- C. Lay Out Subsequent Joists
 1. Continue to slide framing square along top plate from left to right
 2. Align each 16" dimension, inside of body, with left side mark of last joist laid out
 3. Square tongue with top plate and mark line each side - mark "J" between lines
- D. Lay Out Last Joist
 1. Slide framing square along top plate
 2. Align outside of tongue to inside of end wall top plate
 3. Square tongue with plate and mark line each side - mark "J" between lines
- E. Lay Out Extra Joists
 1. On top plates between which openings occurs
 2. Use steel measuring tape, try square
 3. Measure accurately, dimensions indicated on framing plans
 - a. From end of building line to opening
 - b. Width of opening

4. Lay Out Common Rafters
On 16" Centers
 - A. Lay Out First Rafter
 1. On side wall top plates
 2. On ridge board
 3. Start at one end (same end as ceiling joists)
 4. Work across length of building simultaneously with joists
 - B. Lay Out Second Rafter
 1. Flush with end wall top plate
 2. Measure 1 1/2"
 - a. From end wall building line
 - b. Along side wall top plate
 3. Mark line square across top plate at point measured
 4. Mark "R" at end of plate
 - C. Lay Out Subsequent Rafters
 1. Position framing square on top plate
 - a. With face up
 - b. Inside of body to far side of plate
 - c. Tongue across top of plate square
 2. Align 15 1/4" dimension, inside of body, with end of plate (building line)
 3. Square tongue with top plate and draw line each side - label "R" between lines
 - D. Lay Out Last Rafter
 1. Slide framing square along top plate from left to right
 2. Align each 16" dimension, inside of body, with left side mark of last rafter laid out
 3. Square tongue with top plate and mark line each side of tongue
- NOTE: Right side of second rafter should touch left side of second joist
- NOTE: Right side of rafter should be common to left side of joist
- NOTE: Before moving scaffolding to continue joist layout, start rafter lay out on the same plate and develop both lay outs as far as possible before moving the scaffolds
4. Mark lines square on top of plate each side of opening
 5. Mark lines square 1 1/2" each side of opening
 6. Mark "T" for trimmer in 1 1/2" spaces

II. PRESENTATION (CON'T)

V-A-1(S)

5. Lay Out Common Rafters
On 24" Centers
 1. Use steel tape measure and try square
 2. Start at same end, work across length of building
 3. Stretch steel tape along top edge of rafter plate and hold taut
 - a. From end building line
 - b. In direction of layout progression (left to right)
 4. Place try square on 1 1/2" mark and draw line square on top of plate
 5. On 2' intervals (2, 4, 6, 8, etc.) place try square 3/4" each side and mark lines square to plate
 6. Adjust (move) tape as necessary to continue length of building
 7. Mark last rafter 1 1/2" from opposite end
6. Transfer Rafter Lay Out
To Ridge Board
 1. Position ridge board
 - a. On edge
 - b. To inside edge of side wall plate
 - c. On top of wall partition, end wall plates
 - d. With joints properly positioned at rafters
 - e. With ends extended sufficient for overhang
 2. Allow 1/16"+ clearance between rafter plate and ridge board for blade of try square
 3. Temporarily toenail ridge board to top plates to hold in place
 4. Position try square on ridge board
 - a. With handle flat on top
 - b. With blade to side between ridge board and top plate
 5. Mark ridge board
 - a. Slide try square along ridge squarely
 - b. Align blade with rafter marks on top plate
 - c. Transfer marks to face of ridge board
 - d. Transfer marks across top of ridge board to opposite side
7. Lay Out Gable End Studs
On 16" Centers
 1. On end wall top plates
 2. One wall at-a-time
 3. Locate center of building width
 4. Determine regular stud closest to building/ridge center

5. Transfer location "inside edge of stud closest the ridge center" to the top plate
 - a. With square and pencil
 - b. Draw line aligned to stud
 - c. Vertical across edges of top plates
 - d. Square across top plate
6. Position framing square on top plate
 - a. Face up
 - b. Inside of body to far side of plate
 - c. Tongue across top of plate
7. Align 16" dimension, inside of body, to mark on top plate
8. Draw line inside of tongue, squared on top plate
9. Slide framing square along plate and perform key points #7 and #8 until all gable end studs are laid out

III. APPLICATION (PRACTICE BY LEARNER UNDER CLOSE SUPERVISION)

- Instructor: Demonstrate ceiling joist layout; common rafter layout on a 2" x 4" mock top plate
- Instructor: Emphasize importance of accuracy in lay out; verification of lay out dimensions
- Instructor: Pass out job sheet, task sheets
- Students: Practice job and tasks under close supervision of the instructor

IV. VERIFICATION AND/OR EVALUATION (CHECK ON STUDENT'S ABILITY)

Performance test!

Students lay out ceiling joists on top plate

Students lay out common rafters for gable roof on side wall top plates and ridge board

Students lay out gable end stud locations on end wall top plates

V. SUMMARY (TELL THE STEPS ON PROCEDURE AS TO WHAT, HOW, AND WHY. REVIEW CHECKING STANDARDS. THIS SUMMARY MAY BE GIVEN AT ANY POINT IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENTS.)

Lay out of roof frame components on the building wall's top plates is not difficult when done systematically. On plain gable roofs, both ceiling joists and rafters generally span the narrow portion, or width of the building therefore most of the roof frame lay out will appear on the long front and back side walls.

All lay out should begin at one end - generally the left end - and work across the length of the building; left to right. This is due to the close proximity of ceiling joists and rafters, and ease of lay out. Rafters are placed flush at each end and spaced 16" O.C. from one end. Joists are placed to the inside of each end wall and spaced 16" O.C. adjacent to the rafters.

To lay out with a framing square, place the square face up with the inside of the body flush against the far edge of the top plate and the tongue square across the plate. For the second rafter, set 15 1/4" dimension, inside of the body, on the end of the plate, draw lines square each side of tongue. For second joist, set 16 3/4" dimension, inside of body, on the end of the plate, draw lines square each side of tongue. Note! The left side of joist location and the right side of rafter location are a common line. For all subsequent joists and rafter lay out, set 16" dimension, inside of body, on left mark of previous joist/stud location and draw a line squared on each side of tongue.

Gable end studs are located on end wall top plates. The first gable end stud is located directly over the regular stud nearest the ridge center by transferring lines squared flush to the inside of the stud up and on top of the wall plate. Other studs are located on 16" spacing on the top plate with a framing square similar to rafter and joist lay out, but using the location of the first stud as a base for layout.

SUGGESTED READING FOR STUDENTS:

Guide to Residential Carpentry, Unit 21

Framing, Sheathing and Insulation, Unit 15

THE NEXT LESSON IS: V-A-2(S), "Lay Out Roof Frame on Top Plates - Hip Roof"

JOB SHEET
IN
ROOF FRAMING

V-A-1(J)

JOB: Lay Out Roof Frame on Top Plates - Equal Pitch Gable Roof

DRAWINGS: Architectural floor plans, roof framing plans and details

MATERIALS: 8d duplex head nails

TOOLS AND EQUIPMENT: Framing square, marking pen or pencil, 25' steel tape, claw hammer

GENERAL INSTRUCTIONS: Study architects plans and specifications. Become familiar with overall job - type roof; overall size dimensions. Check size, spacing of rafters; directions, spacing of joists. Note special details such as type of joist splices/joints; extra joists for framing ceiling openings, gable end roof rake. Plan your work! One procedure is as follows:

PROCEDURE AND/OR TASKS: V-A-1(TS), Lay Out and Mark Ceiling Joists on Top Plate
V-A-1a(TS), Lay Out and Mark Ceiling Rafters on Top Plate
V-A-1b(TS), Lay Out and Mark Common Rafters in Ridge Board
V-A-1c(TS), Lay Out Gable End Studs on End Wall Top Plates

TASK SHEET

V-A-1(TS)

TASK: Lay Out and Mark Ceiling Joists on Top Plates
 JOB: Frame a Gable Roof
 TRADE: Building Trades/Carpentry
 TOOLS AND MATERIALS: Framing square, try square, 25' steel measuring tape, marking pen or pencil
 TASK BREAKDOWN:

STEPS	KEY POINTS
1. Study Plans, Specifications	1. Determine direction of joists 2. Determine length/type joist - Single span - Spliced; in line - Lapped over bearing partition 3. Verify joist spacing 4. Locate extra joists (framing for ceiling openings) 5. Become familiar with layout dimensions
2. Set Up Scaffolds	1. Type and size as required - For convenient work height, 3-4 feet - To perform layout on top plates - To be solid and sturdy 2. One wall at-a-time - Start at left end, all layout - Work across length of building - left to right
3. Lay Out First Joist	1. Position framing square - On top plate - Face up - Inside of body to far edge of plate - Tongue across plate 2. Align 3 1/2" dimension, inside of body, with end of plate (building line) 3. Draw a line each side of tongue, squared on plate 4. Mark "J" between the lines
4. Lay Out Second Joist	1. Slide framing square along top plate 2. In direction of next joist - left to right 3. Align 16 3/4" dimension, inside of body, with end of plate (building line) 4. Draw line each side of tongue squared on plate 5. Mark "J" between lines
5. Lay Out Subsequent Joists	1. Continue to slide framing square along top plate from left to right

STEPS	KEY POINTS
6. Lay Out last Joist	2. Align each 16" dimension, inside of body, with left side mark of last joist laid out 3. Draw lines each side of tongue squared on plate and mark "J" between lines
7. Lay Out Extra Joists	1. Slide framing square along top plate 2. Align outside of tongue with inside of end wall top plate 3. Draw line each side of tongue squared on plate and mark "J" between lines 1. That frame ceiling openings 2. Use steel tape and try square 3. Measure accurately along top plate 4. Dimensions indicated on framing plan a. From building line to opening b. Width of opening 5. Mark lines square on top plate each side of opening 6. Mark lines square 1 1/2" each side of opening and mark "T" for trimmer in 1 1/2" spaces
CHECK POINTS:	1. Lay out, all plates begins at same end 2. 1 1/2" offset maintained on outside plates for long joists employing lapped joints 3. Correlates with rafter lay out

TASK SHEET

V-A-1a(TS)

TASK: Lay Out and Mark Common Rafters on Top Plate
 JOB: Frame a Gable Roof
 TRADE: Building Trades
 TOOLS AND MATERIALS: Framing square, marking pen or pencil, try square
 TASK BREAKDOWN:

STEPS	KEY POINTS
1. Study Plans, Specifications	1. Verify rafter size; spacing 2. Become familiar with roofing plans, dimensions
2. Set Up Scaffolds	1. Type and size as required a. For convenient work height, 3-4 feet b. To perform layout on the top plates c. To be strong and sturdy 2. On one wall at-a-time a. Start at left end, all layout b. Work across length of building - left to right
3. Lay Out First/Last Rafter	1. On side wall top plates 2. Flush with outside of end walls 3. Measure in 1 1/2" and mark line square across the top plate
4. Lay Out Rafters 16" O.C.	1. Start at left end - work from left to right 2. Position framing square a. Face up b. On the top plate c. Inside of body to far side of plate d. Tongue across top of plate square
A. First Rafter	1. Align 15 1/4" dimension, inside of body, with end of plate (building line) 2. Draw line each side of tongue squared on plate - mark "R" between lines
CHECK POINTS:	*Location line on right side of rafter should be common with location line for left side of ceiling joist.
B. Subsequent Rafters	1. Slide framing square along top plate from left to right 2. Align each 16" dimension, inside of body, with left side mark of previous rafter laid out 3. Draw line both sides of tongue, squared on the top plate - mark "R" between lines

STEPS	KEY POINTS
5. Lay Out Rafters 24" O.C.	1. Use steel tape and try square 2. Stretch tape a. Straight and taut b. From left to right c. Along top plate 3. At 2' intervals (2', 4', 6', 8', etc.) a. Mark lines square on top plate b. 3/4" each side of interval c. Use try square and pencil d. Mark "R" between lines
CHECK POINTS:	*Location line on right side of every other interval should be common with the location line on the left side of every third ceiling joist

TASK SHEET

V-A-1b(TS)

TASK: Lay Out and Mark Common Rafters on Ridge Board
 JOB: Frame a Gable Roof
 TRADE: Building Trades
 TOOLS AND MATERIALS: Try square, marking pen or pencil, claw hammer, 8d common nails
 TASK BREAKDOWN:

STEPS	KEY POINTS
1. Select Ridge Material	1. As per plans and specifications a. To be straight, free of warp b. To be sound, free of major flaws 2. Lengths so that a. Joints will occur at the center of a rafter with as few joints possible b. To allow sufficient material for overhang
2. Position Material	1. On edge, as it will appear in the frame 2. On top plates of end walls; partition walls 3. Approximately 1/8" inside of, and adjacent to a side wall 4. With joints located at the center of a rafter 5. With sufficient material extended for the roof overhang 6. Temporarily toenail ridge to cross plates during layout
3. Mark Common Rafters	1. Position the try square on the ridge board a. With the handle laying on the top edge b. With the blade down the side between the ridge board and the top plate of the side wall 2. Slide the square along the ridge board 3. Align the blade with each rafter mark on the top plate layout 4. Draw line on face of ridge board in line with the rafter line on top plate 5. Transfer the line up and over the top of the ridge board to the opposite face using the try square

TASK SHEET

V-A-1c(TS)

TASK: Lay Out Gable End Studs on End Wall Top Plates
JOB: Frame a Gable Roof
TRADE: Building Trades
TOOLS AND MATERIALS: Framing square, marking pen or pencil
TASK BREAKDOWN:

STEPS	KEY POINTS
1. Study Plans, Specifications	1. Become familiar with plans, details 2. Determine whether gable end studs are balanced or offset with ridge center 3. Verify location, spacing of gable end studs
2. Locate First Gable End Stud	1. Directly over regular stud closest to the ridge center 2. With a framing square and pencil a. Transfer lines "each edge of stud" b. To top plate squarely
3. Locate Other Gable End Studs	1. Use location of first stud as a base for dimensions 2. Position framing square on top plate as in rafter lay out a. Face up b. Inside of body to far side of plate c. Tongue across top of plate 3. Align 16" dimension, inside of body, to left mark of previous rafter laid out 4. Mark line both sides of tongue - mark "X" between lines

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

V-A-2(I)

SUBJECT: Ceiling Joists

AIM: The student(s) will be able to explain the purpose and function of ceiling joists in a house and describe the proper procedure for installing the same.

TEACHING AIDS: Information Sheet V-A-2(IS)
Assignment Sheet V-A-2(AS)

MATERIALS: None

REFERENCES: Wagner, Willis H., Modern Carpentry, Unit 8
Feirer, John L., and Hutchings, Gilbert R., Guide to Residential Carpentry, Unit 16

PREREQUISITE EXPERIENCE OF THE LEARNER: The student(s) must have successfully completed Major Blocks III and IV and continue to display sincere desire to learn the building trades.

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Ceiling joists are horizontal structural members that support the finish ceiling and floors of occupied space above the ceiling. In addition, the ceiling joists act as tension members to resist the outward thrust of the rafters. Ceiling joists are usually located across the width of the building and, in plan, parallel to the rafters. There are two basic methods of roof framing for multi-member construction: trussed roof construction and conventional roof construction. Trusses are prefabricated assemblies placed on the building and attached as a unit. Designed and based on the rigidity of the triangle, a series of trusses form the roof frame. The lower chords in the trusses serve as ceiling joists, and the upper chords serve as rafters. In conventional roof construction, the ceiling joists and rafters are laid out, cut, and fastened to the building one piece at a time. Since ceiling joists are installed immediately prior to rafters, some consider it separate from roof framing. Others, due to the proximity of ceiling joists and rafters, and the special considerations which must be given each during layout and installation, consider ceiling joists an integral part of roof framing.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Purpose, Function	1. Primary a. Support the finish ceiling b. Act as tension members to resist outward thrust of rafters

- 2. Secondary
 - a. Support floor of occupied space above
 - b. Add stiffness (bracing) to total building framework
- B. Location; Description
 - 1. Horizontal structural members
 - 2. Similar to floor joists with exceptions
 - a. Lighter members used
 - b. No header joists around outside
 - 3. Usually span narrowest part (width) of building
 - 4. Normally parallel (in plan) with rafters
 - 5. Set on edge on top plates in a series
 - a. Ends of joists flush with outside of wall frame
 - b. Tops may have to be cut to match slope of roof
 - c. Sides toenailed to top plates with 10d nails
 - 6. May be supported intermediately by
 - a. Load bearing partition walls
 - b. Flush ceiling beams
 - c. Ceiling strongbacks
 - 7. May be jointed and spliced or lapped over intermediate supports
- C. Sizes
 - 1. Usually specified in builder's plans and details
 - 2. May be determined by ceiling joist tables
 - a. Tables calculated using nonstress graded lumber
 - b. Table based on 20# sq. ft. live and dead load.
 - c. Discuss "sizing" using tables
- Passout: V-A-1(IS)
- D. Special Framing

Ref. V-A-1(IS)

 - 1. Stub Joists
 - 1. Used with low-pitched hip roof
 - 2. First joist may interfere with hip rafter
 - 3. Stub joists installed at right will correct
 - 2. Ceiling Openings

(Access ways)

 - 1. Frame similar to floor joists
 - 2. Lay out/install trimmer joists
 - 3. Lay out/install header, tail joists

Note: Double trimmers usually not necessary

 - 4. Maintain regular joist spacing

3. Long Joist Spans

1. Use of flush beams
 - a. Types
 - b. Installations
2. Use of strongbacks
 - a. Types
 - b. Installation
3. Use of joints, splices, laps over bearing partitions
 - a. Types
 - b. Installation

4. Blocking Between Joists

1. Supports non-bearing partitions parallel to joists
2. End nailed between joists straddling partition at approximately 4'-0 intervals
3. Blocks toenailed to top of partition wall

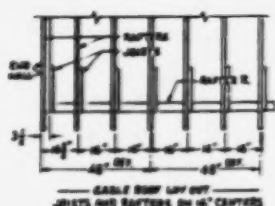
5. Joist Hardware

1. Joist connectors (splice)
2. Framing anchors
3. Joist hangers
4. Metal straps

E. Joist Lay Out

1. Performed on top plates; ceiling beams
 2. Must be coordinated with rafter lay out
- Note: Ceiling joists usually span width of building and are parallel with rafters. Lay out and installation is similar to floor joists except there is no header

1. Gable Roof



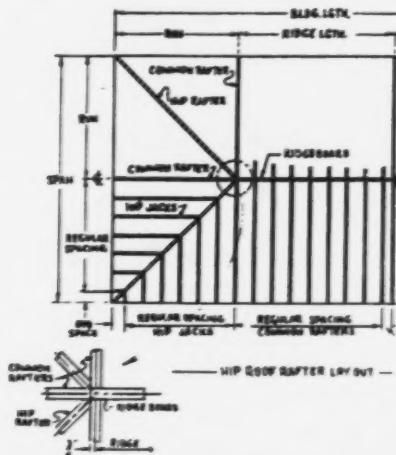
1. Start at one end and continue across the length of the building
2. Place first joist to the inside edge of the end wall

NOTE: This provides a nailing surface for the edge of the ceiling; clearance for the gable end frame

3. Place second joist 16 3/4" from the end of the building/wall line
4. Space other joists 16" O.C. or 16" from edge to corresponding edge
5. Place extra joists (trimmers for openings) without altering spacing of prime joists
6. Place last joist to inside edge of opposite end wall similar as first joist
7. Allow last space to fall where it may short of regular joist spacing

2. Hip Roof

1. Determine the length of the ridge board
 - a. Subtract two building runs from building length
 - b. Add one rafter thickness



F. Installation Procedure

2. Locate ridge board length on side wall top plates
 - a. Measure run minus 3/4" from one end of building
 - b. Measure length of ridge board length
3. Lay out common rafters
 - a. On side wall top plates
 - b. Between length of ridge board marks
 - c. Place first and last rafter flush with ends of ridge board
 - d. Maintain 16"-24" spacing from one end - allow last space to fall short
 - e. Center on, each end wall top plate
4. Lay out hip jack rafters
 - a. Work from common rafters toward corners of building
 - b. Maintain 16"-24" spacing
 - c. Allow odd space to fall at corner

1. Start at one end of building - work across the structure
2. Install one joist at a time
3. Sight down edge of joist and turn crowned edge up
4. Position joist
 - a. To proper mark on outside wall plate
 - b. End even with outside of plate
5. Nail joist to one side wall plate
 - a. Use (3) 10d common nails
 - b. Toenail each side - stagger
6. Check joists to be straight along top and plumb
7. Nail joists to plate at opposite side wall plate - similar as first
8. Nail joists where they join or lap
 - a. Type joint as per plans and details
 - b. Use appropriate splices, connectors
 - c. Use appropriate nails, nail patterns
9. Nail joists to all top plates they may cross
 - a. Check partition wall to be straight and plumb
 - b. Check joists to be straight; on marks
 - c. Toenail joists to plate using (3) 10d common nails

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS, OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSIONS.)

Instructor: Pass out: Information Sheet V-A-2(IS), "Ceiling Framing"

Assignment Sheet V-A-2(AS), "Ceiling Joist Layout"

Students: Read and review information sheet V-A-2(IS), Ceiling Framing
Complete assignment sheet V-A-2(AS), as per instructions.
Submit to instructor for grade

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

Recall

1. What are the two major methods of multi-member roof framing?
Answer: 1. Trussed roof construction
2. Conventional roof construction
2. What are the primary functions of ceiling joists?
Answer: 1. Support the finish ceiling
2. Act as tension members to resist outward thrust of rafters
3. What are two methods of joining ceiling joists on top of a partition plate?
Answer: 1. In line butt joint using splice plates or metal connectors
2. Lap joint face nailed with 10d common nails
4. What must be done before joists are joined at the partition plate?
Answer: Outside walls must be checked to be straight at the top and plumb.
5. Why is the first and last joist placed to the inside edge of end walls?
Answer: 1. To provide a nailing surface for the edge of finish ceiling
2. To allow clearance for a gable end wall
6. What direction do ceiling joists normally run?
Answer: 1. Across the width/narrow part of the building
2. Parallel with the rafters
7. Why is the second joist located 16 3/4" from edge to end of building?
Answer: To clear the second rafter which is 16" O.C. from end of building
8. When are stub joists used?
Answer: When hip rafters have such a low pitch they will interfere with the end joists
9. How is a large ceiling opening framed?
Answer: Similar to floor openings using trimmers, headers, and tail joists
10. What is the purpose of flush beams; strongbacks?
Answer: They support centers of joists with long, clear spans

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

There are two basic methods of roof framing for multi-member construction: trussed roof construction and conventional roof construction. Trusses are prefabricated assemblies delivered to the site and placed on the building as units, in a series. The lower chords of these trusses serve as ceiling joists. In conventional roof framing, the ceiling joists and rafters are laid out, cut, and fastened to the building one piece at a time. Due to the close joist/rafter relationship and the special consideration that must be given during layout and installation in the conventional method, and the fact that the lower chord serves as a ceiling joist in truss construction, it is evident that ceiling joists are an integral part of roof framing -- although some builders may refer to it separately as ceiling framing.

Ceiling joists and/or ceiling frame is that part of the roof frame that lies flat on top of the wall plates. Ceiling frame layout and construction is very similar to the floor frame, with the exceptions that there are no header joists around the outside and the framing members are generally lighter. The primary purpose of ceiling joists are to carry the finish ceiling and act as tension members to resist the outward thrust of the rafters. Ceiling joists generally span the narrowest portion (width) of the building and usually run parallel to the rafters. They are horizontal framing members placed on edge in a series and rest on the building wall's top plates. Their size is based on their type of material, and the distance they must span, their spacing, and the load (lbs. per sq. ft.) they must support. This is usually determined by the designer and appears in the plans and details.

Joists of long spans may be supported intermediately by load bearing partitions, flush beams, and/or strongbacks. Long joists may be made of two pieces and joined at these points of support. Special attention should be given during layout and installation to guarantee proper alignment and assembly is maintained. Stub joists, turned 90° to regular joists, may be required at ends of hip roofs having low pitch to prevent interference of joists with hip rafters. Openings in the ceiling larger than one joists spacing are often necessary requiring the cutting of one or more joists. Such openings should be framed similarly to framing floor openings. Extra joists, trimmers for these openings, should be placed without altering the spacing of the regular joists.

Lay out the joists on the top plates. Check builder's plans to verify direction and spacing. Start at one end and work across the building. Place first and last joist to the inside edge of the end walls. Place second joist 16 3/4" from end of building -- maintain spacing (16") from edge to corresponding edge of all other joists -- allow last space to fall where it may, less than 16".

NOTE: Some people like to lay out ceiling joists and rafters at the same time -- especially when they are to be coordinated with each other. Install joists one at a time. Turn crown edge up and place joist on edge to proper marks on outside wall plates -- ends flush with outside of plate.

Check walls to be straight at the top and plumb before nailing joist. Nail joist at the end first. Toenail each side using 10d nails. Nail joists where they join, second; and nail joist to all top plates it may cross, third. Again, check partition walls to be straight and plumb before nailing.

SUGGESTED READING FOR STUDENTS:

Modern Carpentry, Unit 8, pp. 152-155

Guide to Residential Carpentry, Unit 16, pp. 146-155

THE NEXT LESSON IS: V-B-1(I) "Gable Roof Framing"

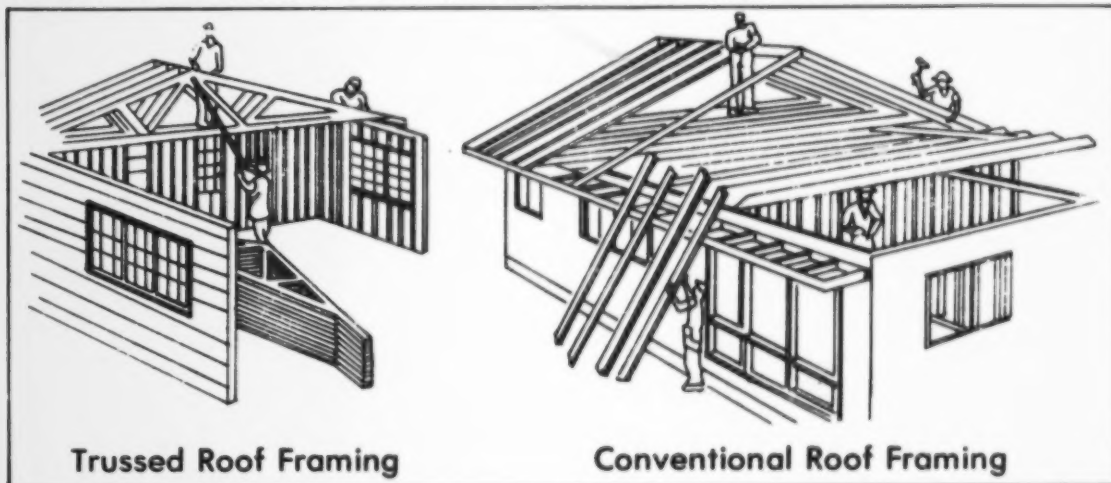
INFORMATION SHEET
ON
ROOF FRAMING

V-A-2(1S)

SUBJECT: Ceiling Joists

INTRODUCTORY
INFORMATION:

There are two basic methods of roof construction in multi-member framing: trussed roof construction and conventional roof construction.

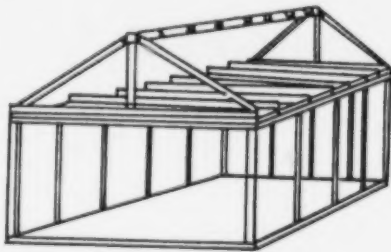


Trusses are prefabricated assemblies delivered to the site and placed on the building as units. In a series they compose a roof frame. The lower chords of the trusses serve as ceiling joists. In conventional roof framing, the ceiling joists and rafters are laid out, cut, and fastened to the building one piece at a time. Due to the close proximity of ceiling joists and rafters and the special consideration given each during layout and installation in conventional construction; and the fact that the lower chord serves as a ceiling joist in truss construction; it is evident that ceiling joists are an integral part of roof framing, although some builders consider ceiling joists separately as ceiling framing.

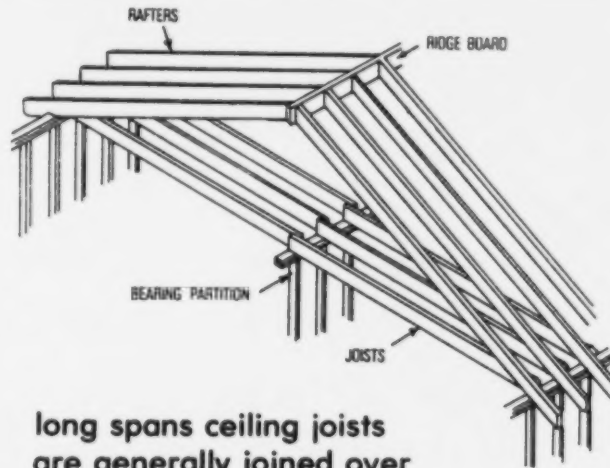
GENERAL INFORMATION:

Ceiling joists and/or the ceiling frame is that part of the roof frame which lies horizontally on top of the wall plates. The primary functions of ceiling joists are to carry the finish ceiling and to act as tension members to resist the outward thrust of the rafters. Layout and installation is very similar to that of floor joists, with the exceptions that there are no header joists around the outside, and, the framing members are generally lighter.

Ceiling joists are generally located across the width of the building and parallel to the rafters. The ceiling joists, turned on edge, rest on the exterior wall plates with the ends even to the outside. The ends usually project above the rafter and must be cut to match the rafter slope.

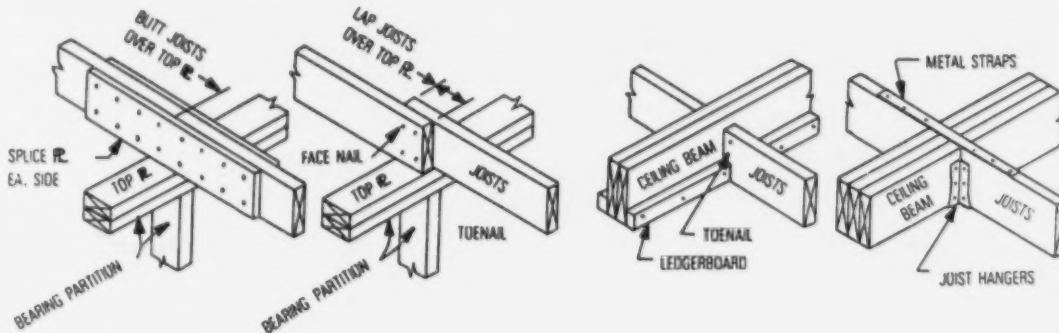


Ceiling joists generally run across the building and parallel to the rafters.



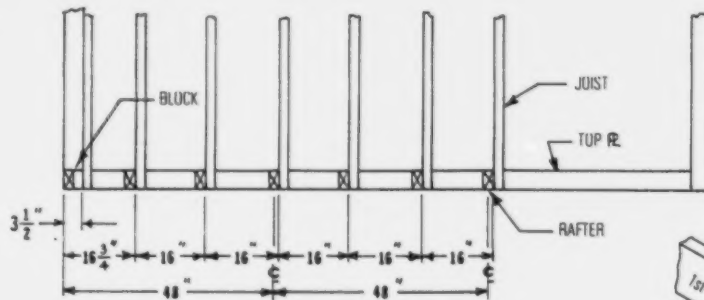
long spans ceiling joists are generally joined over an intermediate support.

Long joists may be composed of two pieces and are joined at some intermediate support such as a bearing partition or a ceiling beam.

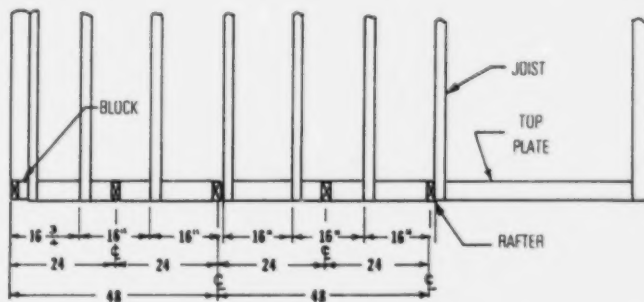


Joist spacing is generally 16" on center. Layout is performed on the top plates. Due to their close proximity with rafters, joist layout cannot be performed without consideration of the rafters.

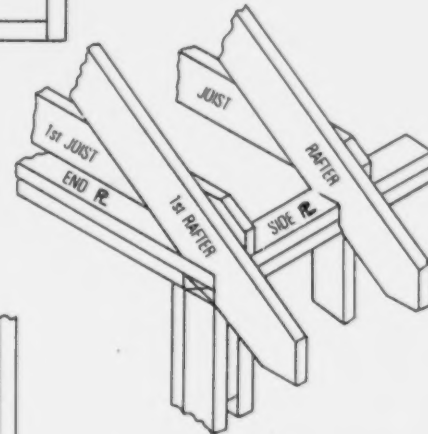
On Gable roofs, layout of both joists and rafters is begun at one end and continued across the structure. Measurements should be made accurately.



Building layout with rafters and ceiling joists on 16" centers.



Building layout with the rafters on 24" centers; ceiling joists on 16" centers.



The first rafter is set flush the outside of the end wall. The first and last joist is set on the inside edge of the end wall to provide a nailing surface for ceiling material.

Place the first joist to the inside edge of the end wall. This allows room to frame the gable end wall and provides a nailing base for the edge of the ceiling material.

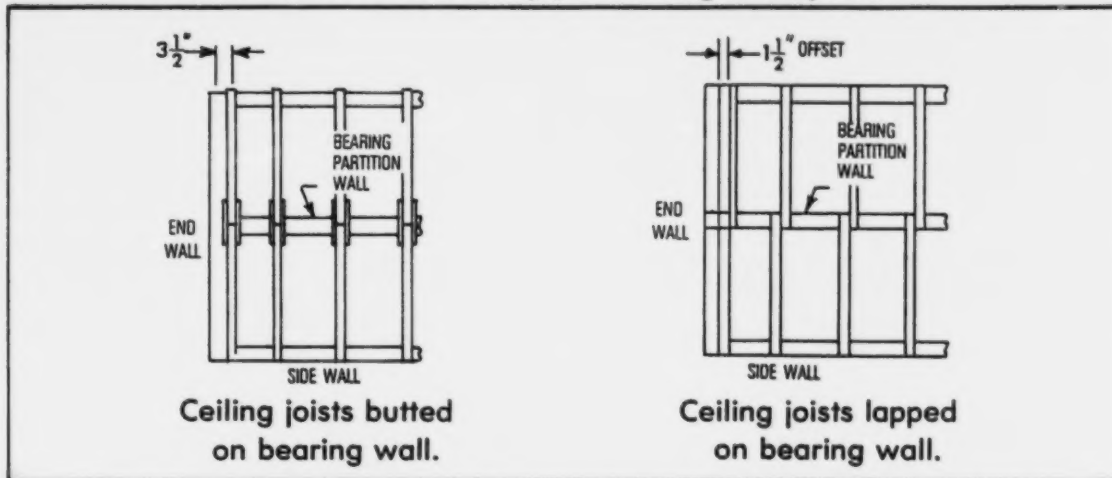
The first dimensioned joist will be 16" or 24", depending on ceiling joist spacing, plus 3/4" to its near edge. This is to coordinate joist layout with the rafters which are generally spaced 16" or 24" on center.

The remaining joists are spaced 16" from a point on one joist to that corresponding point on the next joist.

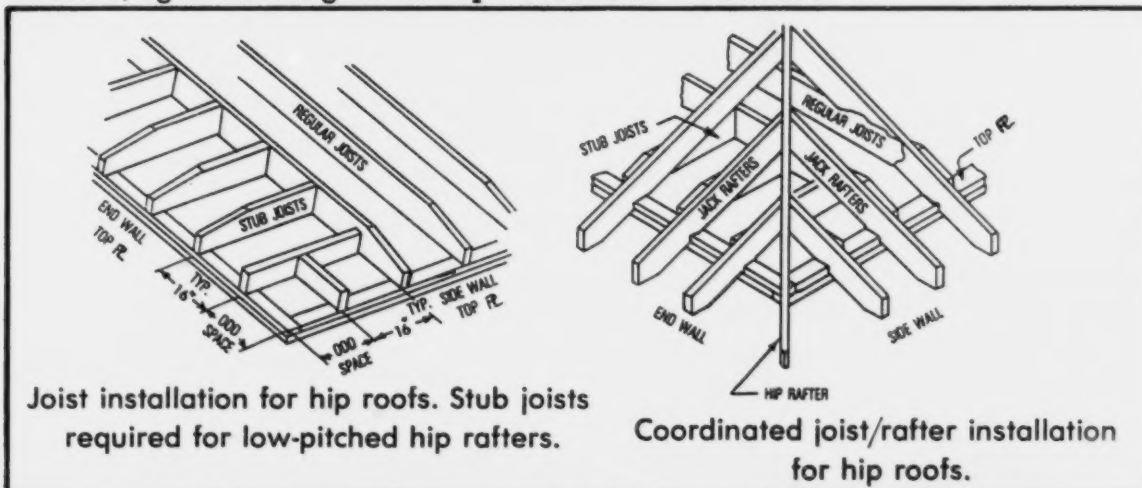
Place the last joist to the inside edge of the far end wall. Allow the last space to fall where it may, short of 16" spacing.

Extra joists (trimmers for ceiling openings, if needed) are placed without altering the spacing of regular joists.

Long joists - composed of two pieces and joined by lapping over bearing partition walls - maintain 1 1/2" offset of lap joint throughout layout.



On hip roofs, ceiling joists layout is coordinated with rafter layout along the side walls, working from the ridge board common rafters toward each end allowing odd space at each end/corner. The end joists, each end, are left out and replaced by stub joists turned 90° and butted into a regular joist. These stub joists are laid out from the common rafter centered with each end wall and coordinated with the hip jack rafters, again allowing the odd space to fall in the corner.



On extremely low-pitched hip roofs, the corner stub joist material may be reduced in size to provide clearance with the rafter bottoms.

The size of ceiling joists is determined by the distance they must span and the load they must carry. The type material--species and grade of wood--are also determining factors. Ceiling joist sizes are generally found on the builder's framing plans and details which also provide directions, spacing, and other details. Material types

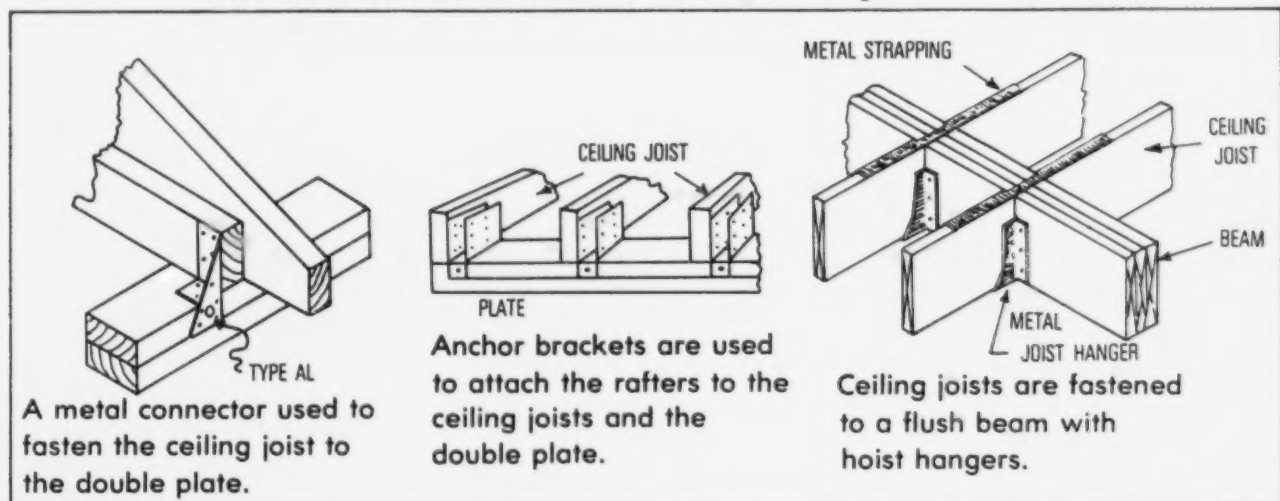
are located in the specifications. However, as a general reference, the following table shows joist sizes, spacing, and span limitations based on non-stress framing lumber.

Size of Ceiling Joists (Inches)	Spacing of Ceiling Joists (Inches)	Maximum Allowable Span (Feet and Inches)			
		Group I	Group II	Group III	Group IV
2 x 4	12	11-6	11-0	9-6	5-6
	16	10-6		8-6	5-0
2 x 6	12	18-0	16-6	15-6	12-6
	16	16-0	15-0	14-6	11-0
2 x 8	12	24-0	22-6	21-0	19-0
	16	21-6	20-6	19-0	16-6

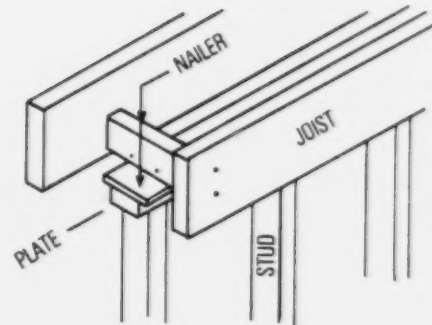
If there are no roof framing plans and details to follow, joist layout and installation should be coordinated with the roof plans as laid out in previous lesson V-A-1 (I).

Installation follows layout! In conventional framing, install one joist at a time. Start at one end and work across the building. Position each joist to the appropriate marks on the top plates--with the crown edge up--with the ends flush to the outside of the exterior walls. Check the exterior walls to be straight along the top and plumb before nailing. Nail joists at the ends, first. Toenail each side to the top plate--use 10d common nails. Nail joists where they join, second; and toenail joists to all top plates they cross, third. Check bearing partition walls to be straight along the top and plumb before nailing.

Note: There is a variety of commercial building products available for installing and securing joists and rafters as shown below. Follow the manufacturer's instructions for use; follow the basic installation procedure described above.



Non-bearing partition walls running parallel with ceiling joists are supported at the top by 2 x 4 blocks set between the joists straddling the partition wall. Place the blocks on edge between, and 90° to the joists at 3'-4' intervals flush with the nailer plate on top of the partition wall. Check the partition wall to be straight at the top and plumb. End nail the blocks to the joists. Spike through the joists! Toenail blocks to partition wall top while wall is straight and plumb.



A nonbearing partition wall is fastened to a block which has been nailed between the joists. Notice the backing which has been attached to the top of the partition for nailing the ceiling material.

ASSIGNMENT SHEET
IN
ROOF FRAMING

V-A-2(AS)
KEY

SUBJECT: Ceiling Joist Plan Layout

AIM: The student will be able to make a ceiling joist framing plan to coordinate with the rafter/roof framing plan.

INTRODUCTORY
INFORMATION:

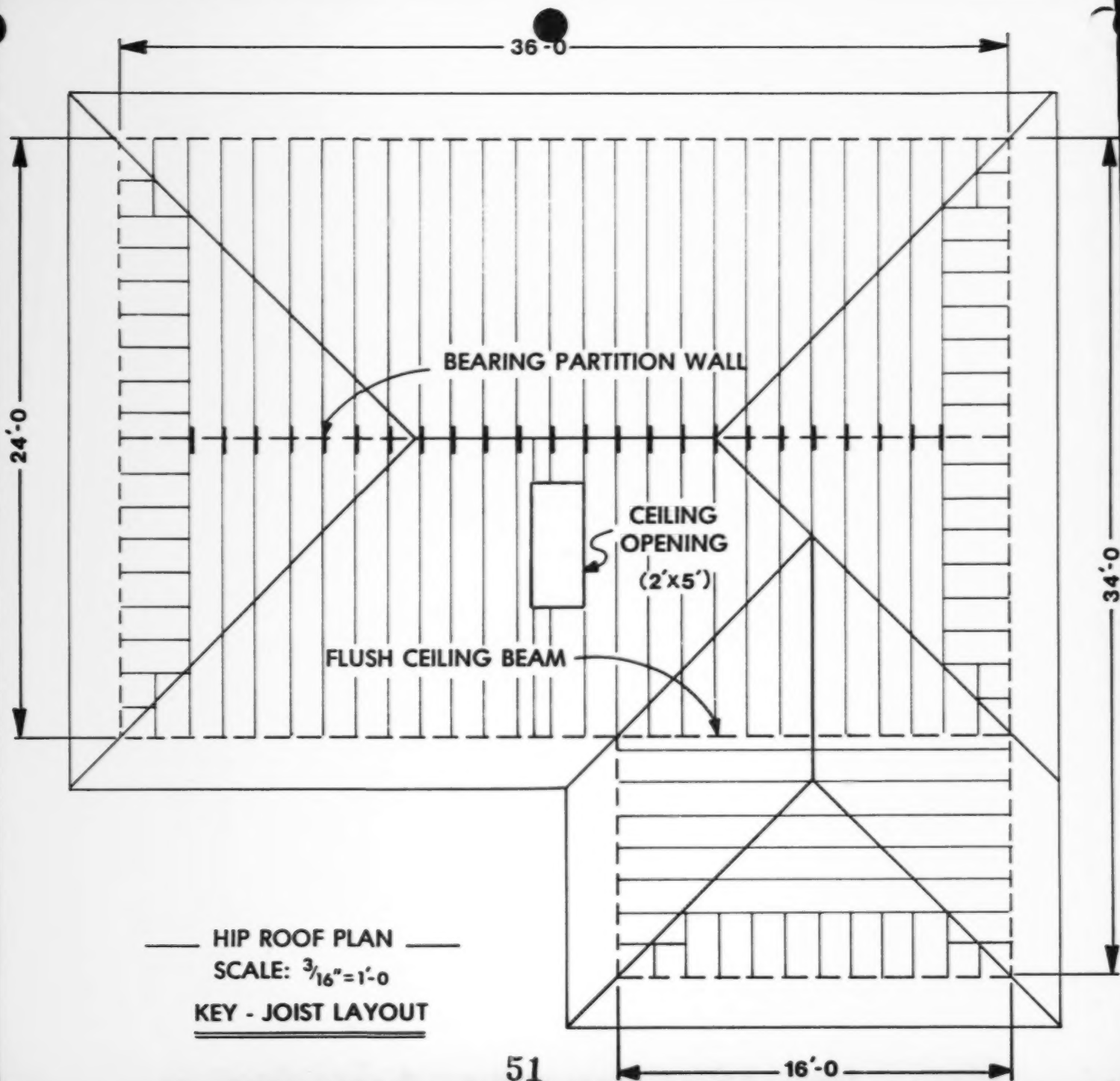
The carpenter must determine the numbers and kinds of framing members necessary to frame the roof. A roof framing diagram may be included among the architect's plans and details. If not, you should lay one out for yourself using the floor plans, roof plans, and exterior elevations and following the procedures presented in lesson V-A-2(I). Joist layout should be coordinated with rafter layout (see previous lesson V-A-1(I) and may be placed on a tracing paper overlay of the floor plans, or it may be drawn directly on the prints.

REFERENCES:

Information Sheet V-A-1(I), Roof Framing; Types, Terminology
Information Sheet V-A-2(IS), Ceiling Joists

QUESTIONS OR PROBLEMS:

1. On the reverse side is a plan drawing of a hip roof showing the building outline and dimensions. Assume the roof has a low pitch! Make a layout of the ceiling joists for framing. Draw directly on the plan shown using a red pencil. Place the joists on 16" centers.
2. Use the joist tables in information sheet V-A-2(IS) to determine the group and size non-stress graded lumber for the greatest span. Group I, 2 x 6
3. Use the size selected for the greatest span throughout to calculate the minimum board feet required to install these ceiling joists. 812 bd ft.
4. Add ten percent to the total for waste. How much would lumber cost for these joists at \$495.00 a thousand board feet? \$442.13
5. To the figure calculated in #4, add an additional \$73.00 for nails and miscellaneous cost. How much would each receive, if two men working on a cost plus 20% basis shared the profits equally? \$51.51



INSTRUCTOR'S PLAN
MANIPULATIVE LESSON

V-A-2(S)

TASK: Lay Out Roof Frame on Top Plates - Equal Pitch Hip Roof

AIM: The student will be able to properly, accurately, and methodically lay out joist and rafter locations on the top plate for a hip roof. In addition, the student will be able to locate and layout rafter locations on the ridge board.

TOOLS AND EQUIPMENT: Framing square, try square, 25' steel tape measure, marking pen or pencil, hammer

MATERIALS: Ridge board - size as per specifications, 6-8d common nails

TEACHING AIDS: Plans and specifications
Job Sheet V-A-2(J)
Task Sheets V-A-2(TS), 2a(TS), 2b(TS), 2c(TS), 2d(TS)

REFERENCES: Wagner, Willis H., Modern Carpentry, Unit 8
Feirer, J.L., and Hutchings, G.R., Guide to Modern Carpentry, Unit 21

CHECKING STANDARDS:

1. Joist direction, spacing
2. Extra joist framing; locations
3. Stub joists locations
4. Rafter spacing

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Again, accuracy of lay out is where it all begins in construction. A construction is no more accurate than its layout. A little extra time spent studying/known the job and thinking through the best procedure before starting is well worth the time that may be saved later due to costly mistakes caused by hurry. "Accuracy of layout" and "double check" are terms to "live by" when performing layout work.

II. PRESENTATION (OF THE SKILLS)

STEPS	KEY POINTS (THINGS TO REMEMBER TO DO OR SAY)
1. Study Plans, Specifications	1. To become familiar with overall roof framing plan and/or diagram 2. To become familiar with dimensions 3. To verify rafter types, location, spacing 4. To determine direction, location, and spacing of ceiling joists 5. To note special joists and locations for framing ceiling/roof openings 6. To calculate ridge board lengths; locations

2. Calculate Ridge Board Length and Location
 1. To find the ridge board length:
 - a. Subtract building width (span) from the building length
 - b. Add ridge board thickness to the result
 2. To locate the ridge board with respect to the building length:
 - a. Subtract ridge board length from building length
 - b. Divide result by two (2)

NOTE: Quotient locates ridge board from one end
3. Locate Ridge Board on Side Wall Plates
 1. One wall at-a-time
 2. From the same end
 - a. Use steel measuring tape
 - b. Along top edge of plates
 3. Measure accurately
 - a. "Location" calculated in step #2-2 above
 - b. "Length" calculated in Step #2-1 above
 4. Mark points measured
 - a. With line squared across top plates
 - b. Use framing square and pencil
4. Lay Out Common Rafters on Side Wall Plates
 - A. Lay Out First Rafter
 1. Position square
 - a. On the top plate face up
 - b. With inside of body to far side of plate
 - c. Tongue across the top plate with the inside edge to the left end mark of the ridge
 2. Draw line outside of tongue squared on plate
 3. Mark "X" between lines
 - B. Lay Out Subsequent Rafters on 16" Spacing
 1. Slide framing square along top plate from left to right
 2. Align each 16" dimension, inside of body, with left side mark of previous rafter lay out
 3. Mark lines each side of tongue squared across plate - mark "X" between lines
 - C. Lay Out Last Rafter
 1. Slide framing square along top plate
 2. Align outside of tongue with right end mark of ridge length

5. Lay Out Common Rafters on End Walls
 3. Mark line inside of tongue square across plate
 4. Mark "X" between lines
 1. One wall at-a-time
 2. Locate the center of the building width (run)
 - a. On the top plate
 - b. From the same side wall building line
 - c. Use steel measuring tape to lay out
 3. Measure 3/4" each side of center location
 4. Mark with lines squared across top plate
6. Mark Common Rafters on Ridge Board
 1. Select ridge material
 - a. Size and type as per specifications
 - b. Lengths so joints are positioned at rafter location, extend beyond end mark
 - c. Straight, free of major flaws
 2. Position ridge board
 - a. On edge, as it will stand in roof frame
 - b. On one side wall top plate; flush to one edge
 - c. Ends aligned with ridge location on top plate
 - d. Joints positioned at rafter location
 3. Temporarily toenail ridge board to top plate
 - a. As required to hold in position
 - b. Use 6-8d nails
 4. Transfer marks locating common rafters
 - a. From top plate to ridge board
 - b. Use try square and pencil
 - c. Transfer marks to both sides of the ridge board
7. Lay Out Hip Rafters on Top Plates
 1. Use common rafter as base for lay out
 - a. On end walls common rafter is centered
 - b. On side walls, use first and last rafter
 2. Lay out of hip rafters to the right exactly like common rafters
 - a. Position framing square on top plate
 - b. Slide square along plate in 16" intervals
 - c. Mark both sides of tongue squared on plate

8. Lay Out Full Length Ceiling Joists

3. Lay out of hip rafters to the left is a mirrored procedure
4. Position framing square
 - a. On the top plate, face down
 - b. With the inside of the body to the far side of the plate
 - c. With the tongue across the top plate
 - d. With the 16" dimension, inside of the body, on the right side mark of the common rafter
5. Mark both sides of tongue squared across plate
6. Slide square along plate right to left
 1. On building side walls' top plates
 2. On intermediate partition wall if required
 3. One wall at-a-time
 4. All lay outs from same end of building
 - a. Lay out left to right across length of building
 - b. Coordinate layout with rafter lay out
 5. Position framing square on top plate face up
 - a. At first or second rafter location on the left (to locate first full joist)
 - b. With the inside of the body to the far side of the plate
 - c. With the inside of the tongue across the plate aligned to the right side mark of the rafter
 - d. Mark both sides of tongue squared on the plate

NOTE: Right side of rafter and left side of joist are common line

6. Lay out joists on 16" centers as per joist lay out for gable roof
 - a. Slide framing square along top plate left to right
 - b. Align each 16" dimension, inside body, with left side mark of last joist located
 - c. Mark both sides of tongue squared on the plate

9. Lay Out Stub Joists

1. On end wall top plates
2. Coordinate with end rafters
3. One wall at-a-time
 - a. Start on one side
 - b. Work across width of end wall
 - c. From left to right

10. Lay Out ~~Extra~~ Joists

4. Lay out with framing square similar as side walls
1. For framing ceiling opening
2. Use steel tape and framing square
3. Measure accurately
 - a. Along top plates between which opening occurs
 - b. Dimensions as per framing plan
 - 1) location of opening
 - 2) width of opening
4. Mark with lines squared across top plates
5. Measure 1 1/2" outside each side of opening
6. Mark with lines squared across plates; mark "T" for trimmer between lines

III. APPLICATION (PRACTICE BY LEARNER UNDER SUPERVISION)

Instructor: Demonstrate procedure using framing square; try square
Oral Explanation to accompany demonstrations
Pass out job and task sheets

Students: Practice job and tasks under close supervision of the instructor

IV. VERIFICATION AND/OR EVALUATION (CHECK ON STUDENT'S ABILITY)

Performance Test!

Students lay out the locations of a hip roof frames components -- ceiling joists, rafters, and ridge board -- on the building wall plates to plans and specifications.

V. SUMMARY (TELL THE STEPS ON PROCEDURE AS TO WHAT, HOW, AND WHY. REVIEW CHECKING STANDARDS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENTS.)

Always study the plans and specifications before commencing any job. Become familiar with size, shape, directions, dimensions; note special features, dimensions, etc., and develop a mental plan or procedure for the work to be done. In a lay out of an equal pitch hip roof frame on the top plates, first locate the ridge board with respect to the building length, and lay out the common rafters; second, lay out the hip rafters from the common rafters to the corners; third, lay out the ceiling joists coordinated with the rafters.

To lay out the ridge board, calculate the ridge board length by subtracting the building span from the building length and adding ridge board thickness to the result. To locate the ridge board, subtract the ridge board length from the building length and divide the result by two. Lay out the ridge

location and on the side wall top plates one at-a-time. Use a steel measuring tape and a framing square! Start all lay out from same end; work from left to right; measure accurately; and mark with lines squared across the plate.

The lay out of common rafters for a hip roof is identical to the lay out of the common rafter for a gable roof except the first and last rafters are flush with the end of the ridge board instead of the end of the building. In addition there is one common rafter centered at each end wall.

Hip rafters are laid out from the common rafters to the corners in every instance. When the layout is from left to right, it is exactly like common rafter layout. When the layout is from right to left, it is a mirrored procedure of common rafter layout.

Joist lay out follows rafter layout in a hip roof because ceiling joists are parallel and adjacent to the rafters which are dependent on the ridge location for their placement. However, since the rafters are laid out the full joists can be laid out from left to right starting at the first rafter. Coordinate full joist lay out on the side plates from the same end, coordinate stub joist lay out on the end plates from the same side.

Mark rafter locations on the ridge board by positioning the ridge board on its edge properly located on one top plate. Transfer rafter location lines to both sides of the ridge board using a try square and pencil.

SUGGESTED READING FOR STUDENTS:

Guide to Residential Carpentry, Unit 21
Framing, Sheathing, and Insulation, Unit 15

THE NEXT LESSON IS: V-B-1(S)

JOB SHEET
IN
ROOF FRAMING

V-A-2(J)

JOB: Lay Out Roof Frame on Top Plates - Equal Pitch Hip Roof

DRAWINGS: Architectural floor plans, roof framing plans, and details

MATERIALS: 8d duplex head nails

TOOLS AND EQUIPMENT: 25' steel measuring tape, framing square, marking pen or pencil, claw hammer

GENERAL INSTRUCTIONS: Study architects plans and specifications. Become familiar with overall job - type roof; overall size dimensions. Check types, location, spacing of rafters; types, direction, spacing of joists. Note special features such as ceiling, roof openings; joist splices. Plan your work! One procedure is as follows:

PROCEDURE AND/OR TASKS: V-A-2(TS), Locate and Lay Out Ridge Board on Side Wall Plates
V-A-2a(TS), Lay Out Common Rafters on Top Plates
V-A-2b(TS), Lay Out Common Rafters on Ridge Board
V-A-2c(TS), Lay Out Hip Rafters on the Top Plates
V-A-2d(TS), Lay Out Ceiling Joists on the Top Plates

TASK SHEET

V-A-2(TS)

TASK: Locate and Lay Out Ridge Board on Side Wall Plates
 JOB: Frame a Hip Roof
 TRADE: Building Trades
 TOOLS AND MATERIALS: 25-50' steel measuring tape, try square or framing square, marking pen or pencil
 TASK BREAKDOWN:

STEPS	KEY POINTS
1. Determine Ridge Board Length	1. Subtract two building runs (building span) from the building length <u>NOTE:</u> Result equal theoretic ridge length 2. Add $1/2$ the thickness of a common rafter to each end of theoretic ridge length <u>NOTE:</u> Total equals length of ridge board
2. Calculate Location of Ridge Board With Respect to Building Length	1. Subtract ridge board length from building length 2. Divide result by two (2) <u>NOTE:</u> Quotient locates ridge board from one end
3. Lay Out Ridge Board on Side Wall Plates	1. One wall at-a-time 2. From same end of building 3. Work from left to right across length a. Use steel measuring tape b. Stretch straight, taut along top plate 4. Measure accurately a. "Location" calculated in step #2 b. "Length" determined in step #1 5. Mark with lines squared across top plate
CHECK POINTS:	Double check calculations; layout dimensions

TASK SHEET

V-A-2a(TS)

TASK: Lay Out Common Rafters on Top Plates
 JOB: Frame a Hip Roof
 TRADE: Building Trades
 TOOLS AND MATERIALS: Framing square, marking pen or pencil, 25' measuring tape
 TASK BREAKDOWN:

STEPS	KEY POINTS
1. Lay Out Common Rafters on Side Wall Plates	1. One wall at-a-time 2. From the same end 3. Work from left to right 4. Across length of building
A. Lay Out First Rafter	1. Position framing square a. On top plate face up b. Inside of body to far edge of plate c. Tongue across the plate with inside to left end mark of ridge 2. Draw line square a. Outside of tongue b. Squared across top plate
B. Lay Out Subsequent Rafters	1. Slide framing square a. Along top plate b. From left to right 2. Align each 16" dimension, inside of body a. With the left side mark b. Of the previous rafter layout 3. Draw lines square a. Each side of tongue b. Squared across top plate 4. Mark "X" between lines
C. Lay Out Last Rafter	1. Slide framing square along top plate 2. Align outside of tongue with right end mark of ridge board 3. Mark line inside of tongue squared across plate 4. Mark "X" between the lines
2. Lay Out Common Rafters on End Walls	1. Centered on end wall top plates 2. One wall at-a-time 3. Measure building run a. From same side wall, each end b. Use steel measuring tape c. Measure accurately d. Mark point measured with a line square across plate

STEPS

KEY POINTS

4. Measure $\frac{3}{4}$ " each side of line
5. Mark with lines squared across plate -
with "X" between lines

TASK SHEET

V-A-2b(TS)

TASK: Lay Out Common Rafters on the Ridge Board
 JOB: Frame a Hip Roof
 TRADE: Building Trades/Carpentry
 TOOLS AND MATERIALS: 25' steel measuring tape, try square, marking pen or pencil
 TASK BREAKDOWN:

STEPS	KEY POINTS
1. Select Ridge Board Material	1. Size and type as per specifications 2. Lengths so that joints are positioned at a rafter location 3. Straight, free of major flaws
2. Position Ridge Material	1. On one side wall top plate 2. On edge, as it will stand in roof frame 3. Flush to one edge of top plate a. Joints positioned at a rafter location b. Ends extend to/beyond ridge end locations 4. Temporarily toenail to top plate a. As required b. To prevent movement during layout c. Use 8d duplex head nails
3. Lay Out Rafter Locations on Ridge Board	1. On one side of ridge board 2. Using try square and pencil 3. Position square against the ridge board a. With the handle flat on the top plate b. With the blade vertical against the side of the ridge board 4. Align outside of blade with rafter layout marks on the top plate, one at-a-time 5. Mark ridge board with lines square and in line to rafter marks on top plate 6. Transfer lines to opposite side a. Use try square and pencil b. Extend lines square c. Over the top; down the opposite side

TASK SHEET

V-A-2c(TS)

TASK: Lay Out Hip Jack Rafters On Top Plates
 JOB: Frame a Hip Roof
 TRADE: Building Trades/Carpentry
 TOOLS AND MATERIALS: Framing square, marking pen or pencil
 TASK BREAKDOWN:

STEPS	KEY POINTS
	<u>NOTE:</u> To lay out hip rafters, work from the common rafters to the building corners. Work may be from left to right, or from right to left
1. Lay Out First Hip Jack (Left to Right)	1. Position framing square a. On top plate face up b. Inside of body to far side of plate c. Tongue across top of plate 2. Align 16" dimension, inside of body a. To left side mark b. Of last common rafter located 3. Draw lines square a. Each side of tongue b. Squared across top plate 4. Mark "X" between the lines
2. Lay out Subsequent Hip Jacks (Left to Right)	1. Slide framing square along top plate left to right 2. Align each 16" dimension, inside of body, with left side mark of last rafter located 3. Mark lines each side of tongue square across top plate 4. Mark "X" between the lines
3. Lay Out First Hip Jack (Right to Left)	<u>NOTE:</u> This is a mirrored procedure of above: 1. Position framing square a. On the top plate face down b. Inside of body to far side of plate c. Tongue across top of plate 2. Align 16" dimension, inside of body a. To right side mark b. Of first common rafter located 3. Draw lines square a. Each side of tongue b. Squared across top plate 4. Mark "X" between lines
4. Lay Out Subsequent Hip Jacks (Right to Left)	1. Slide framing square along top plate right to left

STEPS	KEY POINTS
	2. Align each 16" dimension, inside of body, with right side mark of last rafter located 3. Mark lines each side of tongue square across top plate 4. Mark "X" between the lines

TASK SHEET

V-A-2d(TS)

TASK: Lay Out Ceiling Joists on the Top Plate
 JOB: Frame a Hip Roof
 TRADE: Building Trades/Carpentry
 TOOLS AND MATERIALS: Framing square, marking pen or pencil, 25' steel measuring tape
 TASK BREAKDOWN:

STEPS	KEY POINTS
1. Lay Out Full Length Ceiling Joists	1. On building side walls' top plates 2. On partition wall top plates if required 3. One wall at-a-time 4. Coordinate with rafter lay out, framing plans 5. All lay outs from same end 6. Lay out left to right across length of building
A. Position Framing Square	1. On the top plate face up 2. At first rafter location on left 3. With inside of body to far side of plate 4. With tongue across the plate - inside of tongue to right side of rafter location
B. Mark First Full Joist	1. With lines each side of the tongue 2. Tongue square across the top plate 3. Mark "J" between the lines NOTE: Right side of rafter location and left side of joist location are a common line
C. Mark Subsequent Full Joists	1. Slide framing square along top plate left to right 2. Align 16" dimension, inside of body, with left side mark of last joist located 3. Mark lines on both sides of tongue squared across top plates 4. Mark "J" between the lines
CHECK POINT:	Ceiling joist lay out should be to the right and touching a rafter layout in every instance
2. Lay Out Stub Ceiling Joists	1. On the end wall top plates 2. One wall at-a-time 3. Coordinate with end rafters a. Start on one side

STEPS	KEY POINTS
3. Lay Out Extra Joists	b. Work from left to right c. Work across width of end wall 4. Position framing square a. On end wall b. Same as step #1A, this task 5. Layout and mark stub joists a. On end wall b. Same as steps #1B and #1C, this task
	1. For framing ceiling openings 2. On top plates one at-a-time a. Of side walls and/or partition walls b. Between which trimmer joists are located 3. Use steel tape and framing square 4. Measure accurately; dimensions as per framing plans a. "Location" of opening b. "Width" of opening 5. Mark with lines squared across top plates 6. Measure 1 1/2" outside each side of opening 7. Mark with lines squared across plates; mark "T" between lines each side

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

V-B-1(I)

SUBJECT: Gable Roof Framing

AIM: The student(s) will be able to read and interpret gable roof framing plans; explain in detail, the correct sequence for layout and erection using proper roof framing terminology.

TEACHING AIDS: Framing square, speed square, straightedge clamp (fabricated) Information Sheet V-B-1(IS)

MATERIALS: 2"x 6"x 12' lg. framing lumber

REFERENCES: Wagner, Willis H., Modern Carpentry, Unit 9
Swanson Tool Co. Inc., The Speed Square, booklet

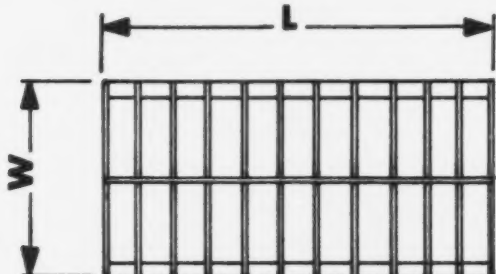
PREREQUISITE EXPERIENCE OF THE STUDENT: The student must have successfully completed previous lessons V-A-1(I) and V-A-2(I) and continue to display a sincere interest in learning the building trades.

I. PREPARATION (OF LEARNER - MOTIVATION)

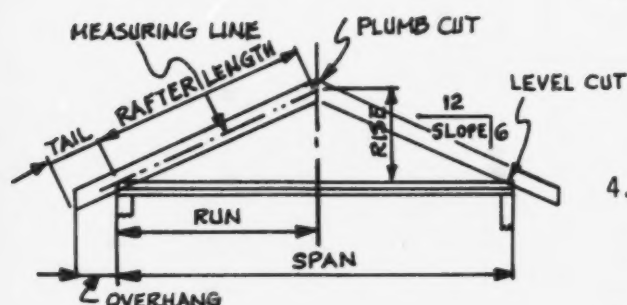
Of the two methods for multi-member roof framing, the "conventional" method of roof framing is still preferred by the practitioners that contract and build single dwelling residences. In conventional roof construction, the carpenter builds the roof with ceiling joists and rafters, a piece at a time, on the building's walls. Rafters are the skeleton of the roof and its loads.

The Gable roof is composed of common rafters. The layout, cutting, and installation of the common rafter (conventional method) will be studied first as it is the basis for layout and installation of other type rafters.

II. PRESENTATION (OF THE INFORMATION)

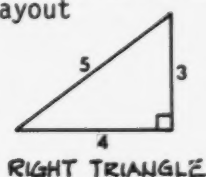
INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Gable Roof 	1. Most used roof style in home building 2. Employs use of common rafters only 3. Sheds water in two directions 4. Slopes (2) meet at a crest or ridge 5. Ridge generally runs with length of building 6. Forms a gable at each end wall
B. Common Rafters 	1. Usually bridge narrow portion (width) of building 2. Are parallel (in plan) with ceiling joists 3. Run at right angles from plates to ridge 4. Tops rest against ridgeboard; are called top, or "plumb" cuts 5. Bottoms rest on plates; are called seat, or "level" cuts

C. Rafter Terms

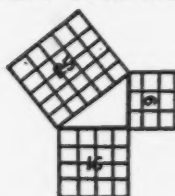


1. Plumb lines - all verticle lines on a rafter placed in its normal position
2. Level lines - all horizontal lines on a rafter in its normal position
3. Slope is the angle a rafter makes with the horizontal
 - a. Determined by "rise" and "run" established by architect
 - b. Expressed as a ratio "rise on run"
 - 1) rise given in inches is variable
 - 2) run given in the unit 12 is constant
4. Pitch is another way of stating angle rafter makes with horizontal
 - a. Determined by "rise" and "span" established by architect
 - b. Expressed as a fraction "rise over span"
5. Span is the width of the building measured out-to-out of exterior wall top plates
6. Run is one-half of span on gable roofs having equal pitch
7. Rise is the vertical distance from the top of wall plates to upper end of measuring line
8. Measuring line - imaginary line which runs from top outside edge of wall plate to center of ridge along the slope
9. Bird's-mouth - a notch cut in the lower edge of rafter to provide level seat to receive wall plates

D. Principles of Rafter Layout



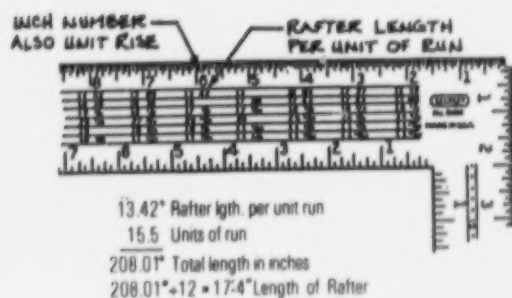
RIGHT TRIANGLE



E. Graphics

1. Based on physical characteristics of right triangles
 2. Is a practical application of geometry
 3. Pythagorean Theorem states, "the square of the hypotenuse of a right triangle is equal to the sum of the squares of the other two sides"
 4. Three methods of finding lengths and cuts of common rafters
 - a. Graphic
 - b. Rafter Tables
 - c. Step-off
- NOTE: The basic principle of all three methods is geometric construction
1. Used primarily by architects, designers, and draftsmen
 2. Layout drawn to reduce scale
 3. Based on Pythagorean's Theorem, right triangles

F. Rafter Tables



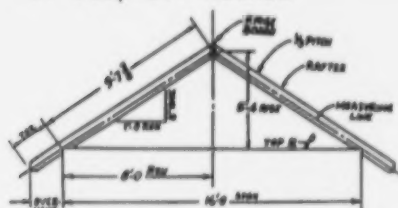
4. Lengths are verified mathematically
5. Little used by carpenters

1. Have pre-calculated rafter lengths per unit run of rafter - unit is 12"
2. One such rafter table is located on the face of the framing square
3. To determine length of common rafters:
 - a. Use "inch number" on outside edge of body to be same as "inches rise" of rafter
 - b. On first line of rafter table below inch no. read, "length of common rafter per foot of run"
 - c. Multiply "length" x total units rafter run
 - d. Convert decimal inches to feet and inches

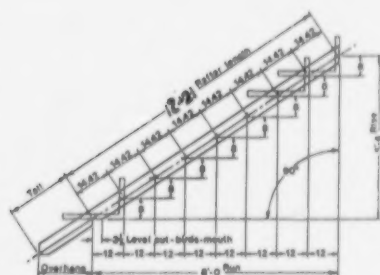
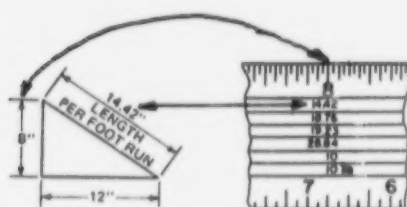
Example: Building span, 31'-0"; Gable roof, 6/12 slope

4. Perform part "A" of Application stage III, of lesson

G. Step-off Method



1. Determine Rafter Length



1. Requires the use of a framing square
2. Is the method preferred by most carpenters
3. May be performed several ways (all are similar)
4. Following is one method of layout:

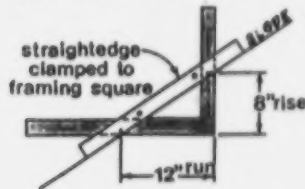
NOTE: Building has gable roof of equal pitch. Assume the roof has a 1/3 pitch, 8" rise per foot of run. The run is 10'-0.

1. Use rafter tables
 2. On face side of framing square
 3. Find number on in scale at top edge of body that corresponds to rise in inches - 8"
 4. Read on first line directly under number, "length of common rafter per unit run - 14.42"
 5. Multiply length per unit run x no. of units (10) = 144.2"
 6. Convert to feet and inches = 12'-2 3/8"
 7. Allow extra length for rafter tail and/or plumb cuts each end
- NOTE: Tail length may be calculated along with rafter length or in addition to rafter length

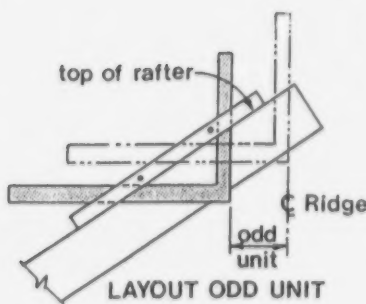
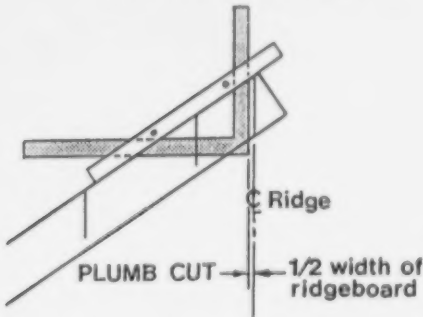
2. Select Rafter Material

Passout: V-B-1(IS)

3. Set Rise and Run



4. Lay Out Ridge, Plumb Cut, Odd Unit Run



1. For pattern rafter
2. To be straight, free of major flaws
3. Length based on calculations as above
4. Size based on rafter span, spacing, slope, and roof loads
 - a. Refer to chart, "Max. Span For Rafters"
 - b. Discuss selection of rafter sizes

1. On framing square
2. With wood straightedge clamp diagonally across face
 - a. Straightedge to - 12" mark (run) on outside of body
 - b. Same edge to 8" mark (rise) on outside of tongue

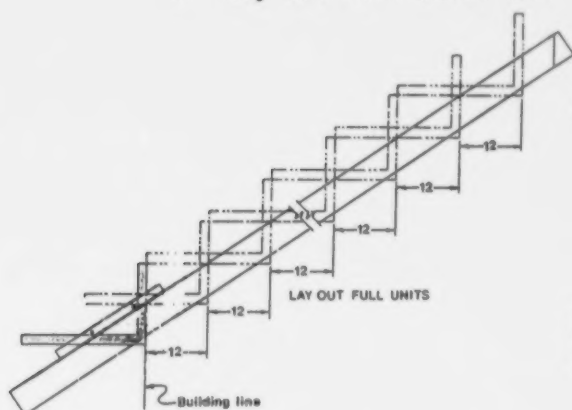
1. Position rafter for layout
 - a. Horizontally
 - b. On saw horses, other...for convenient layout
2. Position framing square and straightedge
 - a. On top edge of rafter
 - b. At top end of rafter
 - c. With elbow of framing square across face of rafter
3. Mark plumb line (ridge center line or rise)
 - a. on rafter
 - b. outside of tongue
4. Mark level line (12" run)
 - a. On rafter
 - b. Outside of body

NOTE: With framing square still in position:

5. Measure and mark "1/2 ridge board thickness"
 - a. Along level line
 - b. Outside of body
6. Measure and mark location of odd unit of run (if any)
 - a. Along level line
 - b. Outside of body
7. Slide straightedge along rafter top edge
 - a. In direction from top to bottom of rafter slope
 - b. Until outside of tongue is aligned with "1/2 ridge board thickness"
8. Mark ridge plumb cut
 - a. On rafter
 - b. Outside of tongue
9. Side straightedge down rafter top
 - a. To align outside of framing square tongue
 - b. With measured mark for odd unit run
10. Mark plumb line (odd unit) on outside of tongue

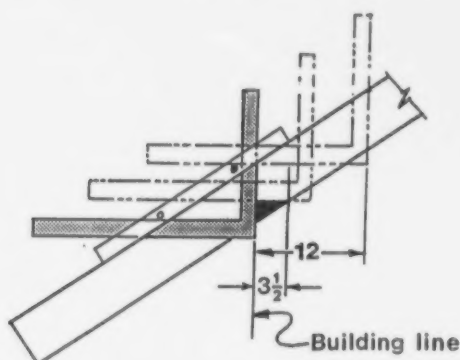
NOTE: With framing square still in position:

5. Lay Out Full Units Run



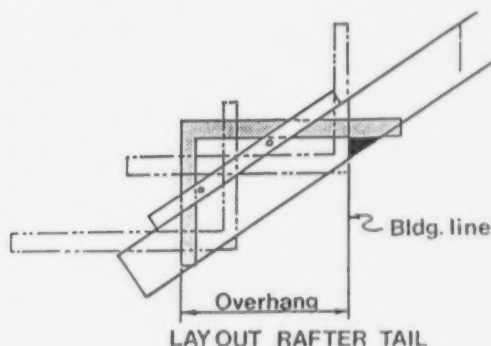
1. Mark level line (12" run) full unit
 - a. While framing square tongue is still aligned with odd unit measurement
 - b. Use a sharp pencil
2. Slide straightedge along rafter top
 - a. In direction from top to bottom of rafter slope
 - b. Until outside edge of tongue is aligned with intersection of level line drawn previous and top of rafter
3. Mark plumb line on outside of tongue
4. Mark level line on outside of blade
5. Repeat keypoints 2,3,4, above, until all full units; total run is stepped-off (laid out)

6. Lay Out Bird's-Mouth



1. Measure back 3 1/2", or width of wallplate
 - a. On body of framing square
 - b. While still positioned for last full unit layout
 - c. Mark point measured on rafter
 2. Slide straightedge along top edge of rafter
 3. Align outside of tongue with 3 1/2" mark measured
 4. Draw plumb line to bottom edge of rafter
- NOTE:** This marks inside edge of seat, or level cut for bird's-mouth
5. Adjust framing square and straightedge on rafter
 - a. To align outside edge of body (horizontal)
 - b. With 3 1/2" mark at lower edge of rafter
 6. Mark seat cut of bird's-mouth along outside edge of blade

7. Lay Out Rafter Tail



1. Position straightedge and framing square
 - a. On top edge of rafter
 - b. With elbow of framing square across rafter face
 - c. Outside of tongue aligned with building plumb line (last plumb line drawn, step #5)
2. Mark level line (12" run) on outside of body
3. Slide straightedge along rafter top
 - a. In direction of rafter tail
 - b. Until outside of tongue is aligned with intersection of previous level line and top of rafter

II. PRESENTATION

V-B-1(I)

4. Mark new plumb and level lines to outside of tongue and blade
5. Measure and mark any odd unit of overhang
 - a. Along last level line drawn
 - b. While framing square is still in place
6. Mark plumb line, lower end of rafter tail
 - a. At odd unit measurement
 - b. Using tongue of framing square

NOTE: If tail material is too short, framing square and straightedge may be turned 180° on rafter top so that tongue is pointing down

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS, OR ASSIGNMENT, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

INSTRUCTOR: Pass out Assignment Sheet V-B-1(AS)
Discuss assignment instructions with class

STUDENTS: Complete assignment as per instructions
Student exercise-drill! Record answers on assignment sheet

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

Roof Frame problems:

1. A common rafter slope is 5 on 12. The total rise is 60".
What is the total run of the rafters? 12'-0
2. A common rafter has a run of 10'-0. If the rafter is 6 on 12, what is the total rafter rise? 60" (5'-0)
3. A gable roof spanning a 24'-0 wide house has a 1/3 equal pitch. What is the total rise on the roof? 8'-0
4. A gable roof with 1/4 equal pitch rises a total of 5'-0. What is the building's span? 20'-0
5. A common rafter a total rise of 52 1/2" on a 5 on 12 slope. What is the rafter run? 10'-6
6. A gable roof frame has a total rise of 5'-8" with a 1/3 equal pitch. What is the building's span? 17'-0
- * A building measuring 24'x32' has a plain gable roof of equal pitch. The rafters slope 7 on 12 and overhang 1'-6" at sidewalls. Using information sheet V-B-1(IS), rafter tables, other available resources:
7. What is the theoretical length of the rafter(s) in the building? 13'-10 11/16"
8. Using southern yellow pine, what is the normal size material, length, width, thickness, for making these rafters? 2"x6"x16'
9. Spaced 16" on center, how many common rafters are required to fram the above roof? 50

IV. VERIFICATION (CON'T)

V-B-1(I)

10. At \$390.00 M bd. ft., how much would it cost to make the above rafters from standard length materials?

#312.00

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

A gable roof is the most used style roof in homebuilding. The gable roof sheds water in opposite directions, usually the sides, with two slopes meeting at a ridge running lengthwise with the building and forming gable end walls.

Gable roofs are framed with common rafters. common rafters run at right angles from the sidewall's top plates to the ridgeboard. The rafter slope is the angle the rafter makes with the horizontal. It is based on the rise and the run established by the architect.

The run is the horizontal length a rafter spans from outside of wall plates to centerline of ridge. The rise is the vertical distance a rafter travels from the top of the wall plates to intersection of ridge centerline taken at rafter measuring lines; a gaged line passing through the vertex of the bird's-mouth and parallel to the rafter top. The bird's-mouth is a notch cut on the lower side of the rafter to seat the rafter on the wall plate.

Rafter calculations are based on the physical characteristics of the right triangle. The Pythagorean theorem states, "the square of the hypotenuse of a right triangle is equal to the sum of the squares of the other two sides." When two sides of a triangle are known, the third side can be calculated. With rafters, the run (base of triangle) is given; the rise (height of triangle) is given; the hypotenuse (rafter length) may be calculated. Rafter tables are a prime example of these calculations.

The cut of the roof (angle roof makes with horizontal) may be given two ways. Slope, expressed as "X" in 12 (5 in 12) indicated inches of rise per 12" unit run. Pitch, expressed as a fraction indicates a ratio of rise to span-span being twice the run, or building width on equal pitch. Example: 1/3 pitch = 8' rise, 24' span. Total height & width dimensions are usually given on architectural prints.

The layout of rafters using a framing square is a practical appliation of the geometric calculations mentioned above. Set the unit rise and run on the tongue and body respectively, of the framing square. Align these points to the top edge of the rafter; with the elbow across the rafter face near the top end. Mark the unit rise (ridge plumb-cut) and unit run on the rafter. This is one unit! Step-off the next unit by moving the rise (on the tongue) to align with the last run mark at the edge of the rafter & resetting 12" run on blade at edge of rafter. If total run is 10'-0, step-off ten units in this manner. If your layout is accurate the rafter length should be obtained.

SUGGESTED READING FOR STUDENTS:

Wagner, Willis H., Modern Carpentry, Unit 9

Feirer & Hutchings, A Guide to Modern Carpentry, Units 17, 18

THE NEXT LESSON IS: V-C-1(I), Gable End Frames And Extended Roof Rake

INFORMATION SHEET
ON
ROOF FRAMING

V-B-1 (IS)

SUBJECT: Common Rafters

INTRODUCTORY
INFORMATION:

Of the two methods of multi-member roof framing, the "conventional" method of roof construction is still preferred by practitioners that contract and build single residential dwellings. In conventional roof construction, the carpenter lays out, cuts, and builds the roof frame one piece at-a-time upon the building's walls.

The gable roof is the most used type roof in home building. The gable roof sheds water in two directions, usually each side, with the two slopes meeting at a ridge running the length of the building and forming gables at each end wall. The gable roof is framed with common rafters. Rafters are the skeleton of a roof and must be carefully cut and fitted if they are to support the roof and its loads.

GENERAL INFORMATION:

Common Rafters

Common rafters usually bridge the narrow portion (width) of a building. Common rafters run at right angles (90°) with sidewall's top plates and the ridge (ridge board) generally centered with the width of the building. The rafter slope is an angle the rafter makes with the horizontal. This angle is established by the architect with dimensions. Rafter slope is based on the rise and the run.

Rafter Terms

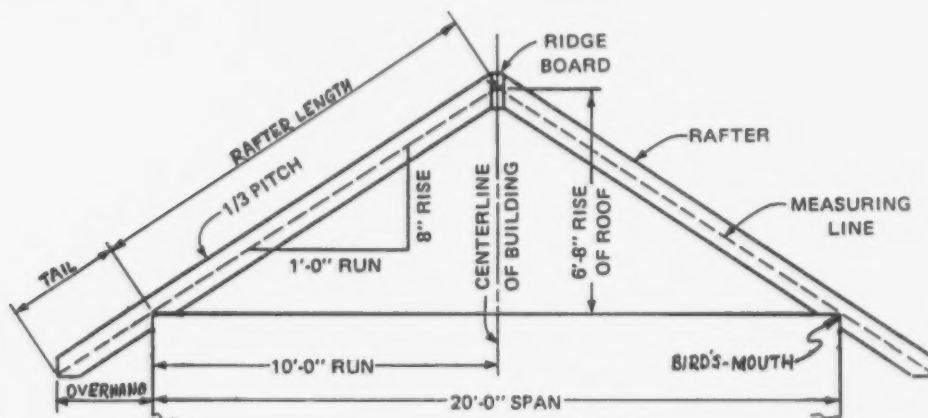


FIG. 1 CROSS-SECTION OF A ROOF

Run - the horizontal length a rafter spans from the outside of the wall plate to the centerline of the ridge.

Span - twice the run on an equal pitch roof; out-to-out of the sidewalls; the building width.

Rise - the vertical distance a rafter rises from the top plate to the intersection of the ridge centerline taken at the rafter measuring line.

Measuring line - a gaged line through the vertex of the bird's-mouth and parallel with the top of the rafter.

Rafter length - is the calculated length from the outside of the top plate to the center of the ridge taken at the measuring line.

Bird's-mouth - is a notch cut squarely in the bottom edge of a rafter to firmly seat the rafter on the wall plate. It is made with a plumb cut and a level cut.

Plumb line, or cut - refers to a vertical line or cut when a rafter is in place.

Level line, or cut - refers to a horizontal line or cut when a rafter is in place.

The cut of the roof - the angle the roof makes with the horizontal and may be given two ways:

Slope - expressed as "X" in 12", indicates "inches" rise per 12" unit run.

Pitch - expressed as a common fraction, indicates the rise over the span.

Tail - that portion of some rafters which overhang the building lines to form an eave.

Rafter Calculations

Rafter calculations are based on the physical characteristics of the right triangle. Pythagorean's theorem states, "the square of the hypotenuse of a right triangle is equal to the sum of the squares of the opposite two sides." When two sides of a right triangle are known, the third side can be calculated.

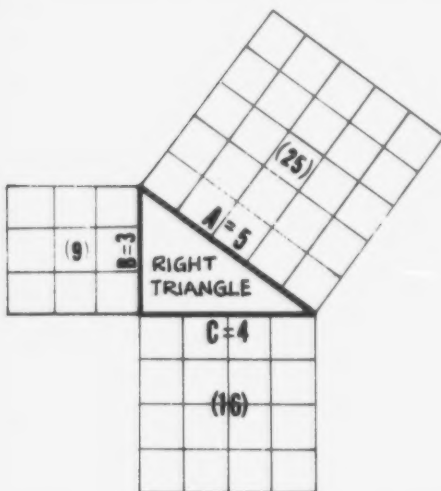


FIG. 2 Pythagorean's Theorem $A^2 = B^2 + C^2$

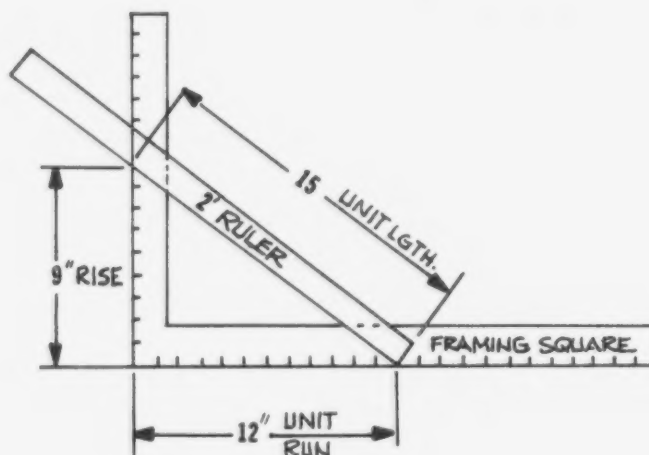


FIG. 3 Lay Out Unit Length Using Framing Square & Rule

A quick check of calculations, or a quick method for obtaining rough/approximate lengths is to lay out the diagonal on a framing square with a ruler and read the

"inches of length per unit" on the ruler. This procedure is especially handy in determining rafter length for material size selection. Simply convert each inch on the ruler to a foot. The length would be 15'-0". It would require a 16' length of lumber, the next standard length over 15', to make this rafter. If the roof has an overhang, add an additional 15" to the rafter length for each 1'-0" of overhang to allow for the rafter tail. For instance, if the same roof has 2'-0" overhang, the rafter would need 15' + 2'-6" (30"), a total of 17'-6" requiring the next standard length of 18'-0" to make the rafter.

Rafter Tables

As rafter tables have already performed these calculations for you, there is no need to figure unit rafter lengths for the various standard slopes. However, you must be able to read and apply these tables. One such table is located on the face of the framing square. To use:

1. Determine the slope-inches rise per unit run - of the rafter desired
Example: Illustration #1 shows 10'-0" run, and 6'-8" (80") rise
 $80'' \div 10 \text{ units} = 8'' \text{ rise per unit run or, 8 in 12}$
2. Locate the inch number on the outside of the body that corresponds with the inches rise per unit run.

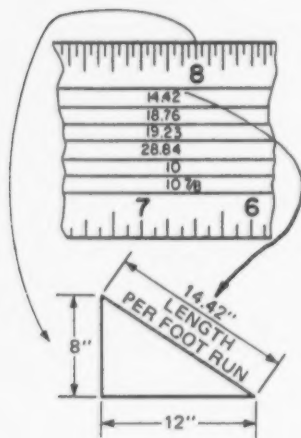


FIG. 4

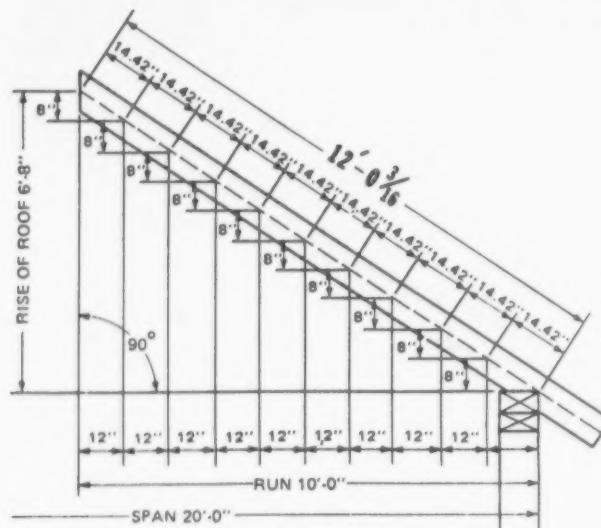


FIG. 5

3. Read "Length of Common Rafter Per Foot of Run" on the first line of the rafter table below the inch number.
4. Multiply "length" read (14.42) x total units of run (10) to obtain rafter length 144.2".

5. Convert decimal inches to feet and inches.

$$144.2" \div 12 = 12.016', \frac{16}{1000} \div \frac{x}{12}, 192 = 1000x, x = .192 = 3/16" \text{ or } 12'-0 \frac{3}{16}"$$

Rafter Material

Sizing rafter material is based on several factors. The type of material, spacing of rafters, rafter span, slope of the roof, weight of roofing materials, and roof loads (wind, weather, snow, and ice) all play a role in determining the size of material of which rafters are made.

Most architects have specified the type and size of rafters along with the necessary dimensions for proper layout and installation. However, in case the carpenter is left to determine the size, the following chart may aid in selecting the appropriate size according to span, spacing, and above normal roof loads.

MAXIMUM SPAN FOR RAFTERS - No. 1 COMMON					
Roof Load of 30 lbs. per Sq. Ft. Uniformly Distributed for Slopes of 20 degrees or more (Note: A 20° slope is approximately a 4 1/4" rise in a 12" run)					
Standard Lumber Sizes		Distance on Center	Maximum Clearance Span - Plate to Ridge		
Nominal Size	Actual Size		South. Pine & Douglas Fir	Western Hemlock	Spruce
2" x 4"	1 1/2" x 3 1/2"	16"	7'-2"	6'-8"	6'-2"
		24"	5'-10"	5'-6"	5'-0"
2" x 6"	1 1/2" x 5 1/2"	16"	14'-0"	13'-8"	11'-2"
		24"	11'-6"	11'-6"	9'-0"
2" x 8"	1 1/2" x 7 1/4"	16"	18'-4"	17'-8"	16'-4"
		24"	15'-8"	15'-8"	13'-4"
2" x 10"	1 1/2" x 9 1/4"	16"	21'-10"	21'-2"	20'-4"
		24"	19'-8"	19'-0"	16'-10"

Rafter Layout Using a Framing Square

Layout should be performed only once - very accurately. The rafter should be cut and a second one made using the first one as a pattern. The two should be checked for fit. Once approved, the original rafter is used as a pattern rafter for other like rafters.

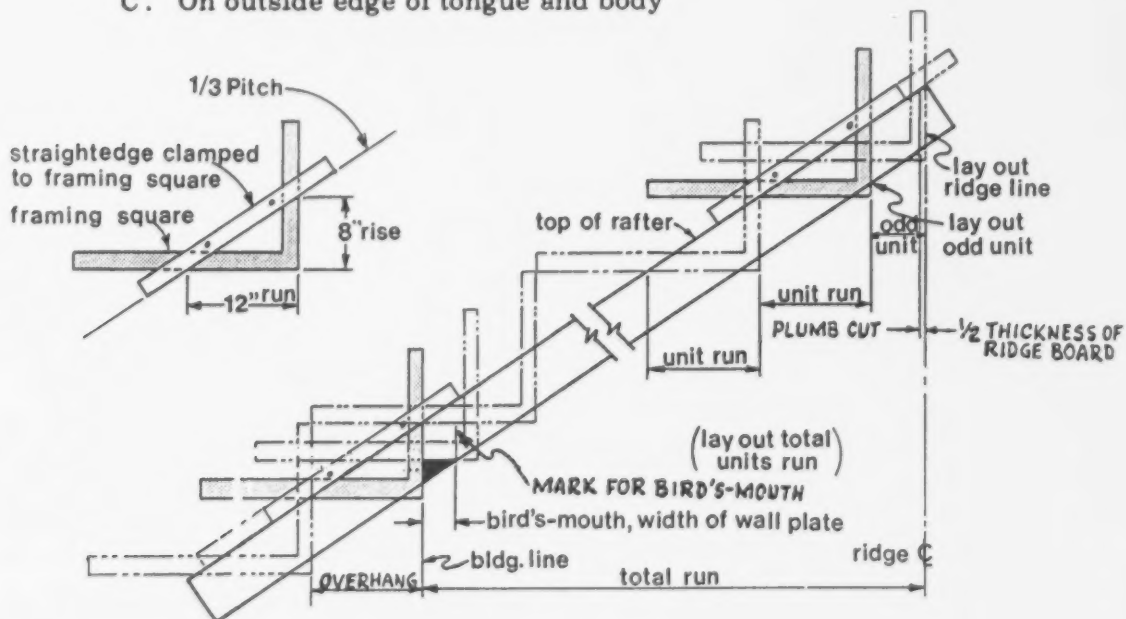
Rafter layout, performed with a framing square, is a practical application of the geometric calculations used to obtain the rafter length.

Lay out is best performed with the aid of a straight edge clamped across the face of the framing square to cut the outside edges of the tongue and the body at the unit rise and unit run inch marks respectively (similar to the rule in Figure 3).

NOTE: Some carpenters make a special straightedge clamp for this purpose by cutting slots through the thickness, each end of a 1 x 2 hardwood, drilling holes through the face, and clamping to the square with machine screws and wing nuts.

To lay out a common rafter:

1. Determine the rafter length
 - A. Obtain key dimensions from architect's prints-span, rise, run, pitch or slope
 - B. Use rafter table to find rafter length per unit run (12")
 - C. Multiply total units run x "Length per unit" (include tail)
 - D. Convert answer to feet and inches
2. Select rafter material
 - A. As per the architect's plans and specifications, or...
 - B. Next standard length over calculated length
 - C. Size as per span, spacing, loads, and material based of chart (Fig. 6)
 - D. Straight and free of warp, major flaws. Position horizontally for layout!
3. Clamp straightedge to framing square
 - A. Diagonally across the face
 - B. At unit rise, at unit run
 - C. On outside edge of tongue and body



RAFTER LAYOUT

4. Position framing square and straightedge on the top edge of the rafter
 - A. Near the top end
 - B. With the elbow of the framing square across the face of the rafter
 - C. Mark plumb line (ridge centerline) along outside edge of tongue
 - D. Mark level line along outside edge of body
5. Lay out odd unit run (if any)
 - A. With framing square still in place, measure length of odd unit
 - B. From corner of square along outside of body - level line
 - C. Mark point measured
 - D. Slide straightedge and framing square along top of rafter to align outside edge of tongue with point measured
 - E. Mark plumb line (odd unit) along outside edge of tongue
 - F. Mark level line (first full unit of run-12") along outside edge of body
6. Lay out full units of run
 - A. Slide straightedge and framing square down the top edge of the rafter to align the outside of the tongue with the point on which the previous level line touches the rafter's top edge
 - B. Mark plumb and level lines along the outside edge of the tongue and body respectively
 - C. Repeat steps 6-A & 6-B until all full units are stepped off

With framing square still in position for last full unit run:

7. Lay out bird's-mouth
 - A. Measure back from 12" mark along level line outside of body 3 1/2", or width of top plate
 - B. Mark point measured
 - C. Slide straightedge and framing square down to align outside of tongue with point measured
 - D. Draw line from point measured to bottom of rafter - locates point of level cut for bird's-mouth
 - E. Slide straightedge along top of rafter to align outside of the framing square body with point of level cut for bird's-mouth
 - F. Draw level line for bird's-mouth along outside of body
8. Lay out rafter tail similar to rafter using step-off method

NOTE: If rafter overhang has odd unit run, treat same as rafter.
If rafter material is not sufficiently long, the straightedge and framing square may be revolved 180% (turned over) to draw the tail plumb cut.
9. Lay out ridge plumb cut

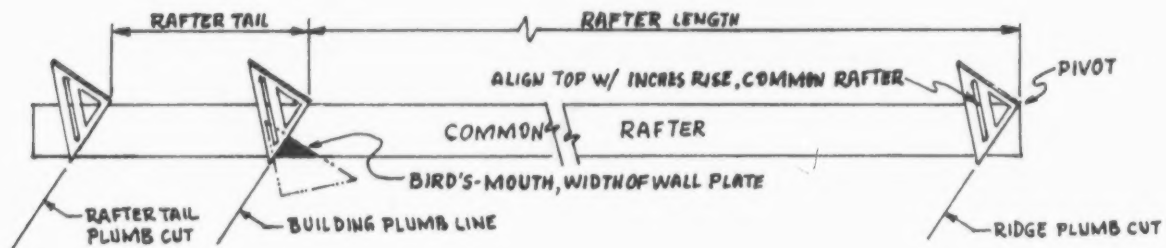
NOTE: This may be done after step #4

 - A. Position straightedge and framing square as in step #4
 - B. Slide straightedge and framing up along top of rafter to align inside of tongue with ridge centerline marked in step #4
 - C. Measure one-half the ridge board thickness along inside of body - mark point measured

- D. Slide straightedge and framing square down to align outside of tongue with point marked
- E. Draw plumb line (ridge plumb cut) through point marked

Rafter Layout Using a Speed Square

1. Determine rafter length - most speed squares are provided with a booklet on its use that includes tables showing rafter lengths per foot of run at various rises - also rafter lengths of varying building widths per rises
2. Select rafter material, determine top edge, and place in horizontal position convenient for layout, the same as for layout with framing square
3. Measure the rafter length and rafter tail (if any) along the top edge of the rafter -- mark points measured
4. Place speed square on face of rafter at one end
 - A. With "T" bar of square over top edge of rafter
 - B. With pivot slot on beginning point of measurements



COMMON RAFTER LAYOUT USING SPEED SQUARE

5. Pivot square so that the top edge of the rafter is aligned with the number corresponding to the rise desired in the window marked "common"
 6. Scribe a line along the leg askew across the end of the rafter while holding square and pivot in place
- NOTE: This marks the top plumb cut or ridge centerline.
7. Mark additional plumb lines at points measured same as steps, 4, 5, and 6 above -- these mark the building plumb line and rafter tail plumb cut
 8. Align engraved mark on face of square with building plumb line so the hypotenuse of square is on desired level cut for bird's-mouth -- mark level cut along edge of hypotenuse

NOTE: Tail may be marked and squared in a similar manner.

ASSIGNMENT SHEET
IN
ROOF FRAMING

V-B-1(AS)
KEY

SUBJECT: Sizing Common Rafters

AIM: The student will be able to calculate rafter lengths, select material size and length to lay out common rafters for a gable roof.

INTRODUCTORY
INFORMATION:

Gable roofs shed water in two directions. Gable roofs are composed of common rafters which meet at a ridge (crest of the roof) and slope toward the outside wall plates.

Plain gable roofs generally span the building width and are of equal pitch; that is, the ridge is centered with the building width and runs the length of the building.

Rafter lengths are based on the roof rise and the run given on architectural prints. Rafter tables (framing square) have pre-calculated lengths per unit run, 12". Rafter tables, Swanson's booklet, the Speed Square, gives rafter lengths per inch rise for building widths. Rafter sizes are based on rafter spans, rafter spacing, rafter material (type), and rafter/roof loads. Other tables provide maximum spans per material type and size according to slope, spacing, and loads; see V-B-1 (IS).

REFERENCES:

Information Sheet V-B-1 (IS), Common Rafters
Booklet, The Speed Square, Swanson Tool Company, Inc.
Rafter Tables, Carpenter's Framing Square

QUESTIONS OR PROBLEMS:

1. The architect specifies 1/3 pitch on an equal pitch gable roof building 28' x 60'. The roof has no overhang. What is the rafter length? 16'-9 7/8"

2. A building 31'-0" wide has an equal pitch gable roof 7'-9" high and eaves that overhang 2'-0". What is the rafter length? 17'-4"

3. A gable roof has a 5 in 12 slope with a 1'-6" overhang. The roof rise is 62 1/2". What is the rafter length (include tail)? 15'-2"

V-B-1(AS)
KEY

4. Rafters whose roof slope is 7 in 12 have a rise of 6'-6 1/2".
With a 1'-6" overhang, how long is the rafter?

12'-8 3/4"

5. A house measures 32' x 56'. It has a plain gable roof on
a 1/4 pitch, a 1'-9" overhang at the eaves. What standard
size and length of southern pine framing lumber is
required to make these rafters, if they are spaced 16" O.C.?

2" x 8" x 20' lg.

6. Given: Building width of 16'-0 with a 5 in 12 slope,
gable roof and 1'-0 overhang on eaves. What standard
size and length of southern pine framing lumber is
required to make rafters if spaced 24" O.C.?

2" x 6" x 10' lg.

INSTRUCTOR'S PLAN
MANIPULATIVE LESSON

V-B-1(S)

TASK: Lay Out and Cut Common Rafters

AIM: The student will be able to lay out and cut common rafters according to the dimensions provided on the architectural prints.

TOOLS AND EQUIPMENT: 25' steel measuring tape, framing square, marking pen or pencil, saw horses, portable circular power saw, extension cord

MATERIALS: Framing lumber, size and type as per specifications

TEACHING AIDS: V-B-1 Job and Task sheets

REFERENCES: Blueprints and specifications

PREREQUISITE EXPERIENCE OF THE LEARNER: The student must have successfully completed previous lessons V-A-1(I), V-A-2(I), and V-B-1(I). The student must continue to display a sincere interest in learning the building trades.

CHECKING STANDARDS: 1. Accuracy of rafter length calculations
2. Selection of rafter material for pattern rafters
3. Accuracy of lay out
4. Fit of pattern rafters

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Common rafters are used exclusively on gable roofs, and extensively on hip, or hip and valley roofs. Common rafters are the first rafters to be laid out, cut and installed on all of these roofs. Common rafters are square and normal with the building lines and generally slope from a center ridge to the wall plates, usually across the narrow portion (width) of the building. The slope of these rafters is determined by their rise and run, dimensions given by the architect/designer in some form on the prints. The carpenter must take the architect's dimensions, lay out and cut the rafters to meet the architect's specifications.

II. PRESENTATION (OF THE SKILLS)

STEPS	KEY POINTS (THINGS TO REMEMBER TO DO OR SAY)
1. Study Plans, Specifications	1. Determine material type, size 2. Obtain key dimensions - rise, run, span, slope, or pitch, overhang if any
2. Calculate Rafter Length	1. Read "length of common rafter per foot of run" a. On body of framing square b. Below "inch number" equal to rise in inches

-
2. Multiply "length" x "units of run"
NOTE: Include overhang in total units of run to obtain total length of rafter
3. Select Rafter Material
1. For pattern rafters (2)
 2. Size, type material as per specifications
 3. Next standard length over calculated length
 - a. Straight, free of warp
 - b. Free of major flaws
4. Position Material
1. On one face
 2. On saw horses, or
 3. On other surface convenient for lay out
5. Set Rise and Run
1. On the framing square
 2. With a wood straight edge
 3. Clamp diagonally across the face
 - a. To 12" mark, outside edge of body
 - b. To "rise" mark, outside edge of tongue
6. Lay Out Ridge Centerline
1. Position framing square and straight-edge
 - a. Along top edge of rafter
 - b. At top end of rafter
 - c. With elbow of square across face of rafter
 2. Mark plumb line (ridge center)
 - a. On rafter face
 - b. Outside of tongue
 3. Mark level line (12" run)
 - a. On rafter face
 - b. Outside of body
- NOTE: With framing square still in position
7. Lay Out Ridge Plumb Cut
1. Measure "1/2 ridge board thickness"
 - a. From the elbow of the framing square
 - b. Along the level line outside of the body
 2. Mark point measured on face of rafter
 3. Slide straightedge along rafter top edge
 - a. In direction from top to bottom of rafter slope
 - b. To align outside of tongue with point measured "1/2 ridge board thickness"
 4. Mark plumb cut line
 - a. Outside of tongue
 - b. On face of rafter

8. Lay Out Odd Unit Run

NOTE: With framing square still in position at step #6

1. Measure "odd unit"
 - a. From elbow of framing square
 - b. Along the level line outside of body
2. Mark point measured on face of rafter
3. Slide straightedge along rafter top edge
 - a. In direction from top to bottom of rafter slope
 - b. To align outside of tongue with point measured "odd unit".
4. Mark "odd unit" plumb line
 - a. Outside of tongue
 - b. On face of rafter

9. Lay Out Full Units Run

NOTE: With framing square still positioned

1. Measure full unit (12")
 - a. From elbow of framing square
 - b. Along outside of body
2. Mark point measured with sharp pencil

NOTE: Mark should fall at top edge of rafter

3. Slide straightedge along top edge of rafter
 - a. In direction from top to bottom of rafter slope
 - b. To align outside of tongue with point measured; full unit, 12"
4. Mark unit plumb line outside of tongue
5. Repeat key points, step #9 until all units have been stepped off (laid out)

10. Lay Out Bird's-Mouth

NOTE: With framing square still positioned for last full unit layout

1. Measure back 3 1/2", or width of wall plate
 - a. From 12" mark
 - b. On outside of framing square body
2. Mark point measured with sharp pencil
3. Slide straightedge along rafter top to align outside of tongue with point measured
4. Draw plumb line to bottom edge of rafter

NOTE: This marks inside edge of seat or level cut for bird's-mouth

5. Slide straightedge along top edge of rafter
 - a. To align outside of body (level)
 - b. With 3 1/2" mark at lower edge of rafter

11. Lay Out Rafter Tail

6. Mark seat cut of bird's-mouth along outside edge of framing square body
1. Position straightedge and framing square
 - a. Straightedge to top edge of rafter
 - b. Elbow of framing square across face of rafter
 - c. Outside of tongue on plumb (building) line
2. Measure full unit (12") one-at-a-time
 - a. From elbow of framing square
 - b. Along outside of body
3. Mark points measured with pencil
4. Slide straightedge along top of rafter
 - a. In direction of rafter tail
 - b. To align outside of tongue with point measured
5. Mark unit plumb lines

NOTE: Last unit may be partial unit. Lay out similar to odd unit step #8. Last plumb line is tail plumb cut of rafter

6. Square rafter tail
 - a. Scribe a line on the face of the rafter
 - 1) parallel to top of rafter
 - 2) passing thru vertex of bird's-mouth and tail "plumb cut" line
 - b. Mark line square with tail plumb cut
 - 1) on face of rafter
 - 2) at intersection of scribed line and rafter tail

12. Cut Rafter Pattern (2)

1. Use portable circular power saw
2. Perform pre-operating safety check
 - a. Personal safety
 - b. Electrical safety
 - c. Tool safety
3. Position rafter material
 - a. Horizontally on one face-lay out up
 - b. On sound work base
 - c. Convenient height for sawing
4. Cut rafter
 - a. Square to the face thru rafters thickness
 - b. With straight, clean lines
 - c. So that the waste is always to the operators right

NOTE: Practice safety in use and handling of portable power saws

13. Check Rafters For Fit

1. As a team
2. Position two common rafters opposite each other

II. PRESENTATION (CON'T)

V-B-1(S)

- a. As they would appear in a roof frame
- b. Use a block of wood the same thickness as ridge for spacer
3. Check cut of rafter; fit of rafter

III. APPLICATION (PRACTICE BY LEARNER UNDER CLOSE SUPERVISION)

Instructor: Demonstrate layout of common rafter using framing square

Passout: V-B-1 Job and Task sheets

Students: Practice job and tasks to specified plans and details under close supervision of instructor.

IV. VERIFICATION AND/OR EVALUATION (CHECK ON STUDENT'S ABILITY)

Performance Test!

Students to layout and cut common rafters according to prints and specifications.

V. SUMMARY (TELL THE STEPS ON PROCEDURE AS TO WHAT, HOW, AND WHY. REVIEW CHECKING STANDARDS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENTS.)

Common rafters are used exclusively on gable type roofs, and extensively on hip, or hip and valley roofs. Common rafters are the first rafters to be laid out, cut, and installed in all of these roofs. Their method of layout is the basis for lay out of the other types of rafters in the same roof.

Common rafters usually span the narrow portion (width) of the building and generally slope from a center ridge to the sidewall's top plates. These rafters are square to normal building lines and lengths are calculated according to vertical rise and horizontal run of its slope.

A common rafter can be laid out with a framing square using the step-off method as follows:

1. Clamp a straightedge diagonally across a framing square so that the edge nearest the elbow is on the 12" mark (run) and the "inches" rise on the outside edge of the body and tongue respectively.
2. Place straightedge to the top edge of the rafter material with the elbow of the framing square across the face of the rafter - at the top end of the rafter.
3. Mark "ridge center" plumb line outside of tongue; layout points for ridge plumb cut (1/2 thickness of ridge board), and odd unit of run from elbow along outside of body.
4. Slide straightedge and with framing square along rafter top; align outside of tongue to each layout point one-at-a-time; mark plumb cut line, odd unit of run outside of tongue.

5. With tongue of square still positioned at odd unit plumb line, layout point for first full unit run on outside of body.
6. Slide straightedge with framing square along top edge of rafter to align outside of tongue with layout point; draw plumb line "full unit", layout point next unit. Continue step-off method of layout for full rafter length.

NOTE: With framing square still positioned for last full unit layout:

7. Measure back 3 1/2" from 12" mark outside of body and mark point; slide straightedge with framing square along top edge of rafter to align outside of tongue with point - draw plumb line to bottom edge of rafter.

NOTE: This marks the inside edge of seat or level cut for bird's-mouth. Adjust straightedge to align outside of framing square body with mark at lower edge of rafter; draw level cut for bird's-mouth

8. Step-off rafter tail similar to rafter length. To square tail scribe line parallel to rafter top thru vertex of bird's-mouth to intersect rafter tail plumb cut line. Draw level line thru intersection of tail plumb cut and scribed line.
9. To cut two rafter using a circular portable power saw, position the rafter material on a sturdy base of convenient height for cutting, follow all safety precautions in the operation and use of the saw, cut lines straight and square through the thickness of the material.
10. Check rafters for fit by positioning them opposite each other as they would appear in a roof frame. Use a block of wood the same thickness as the ridge for a spacer. Use first rafter as a pattern to layout like rafters.

SUGGESTED READING FOR STUDENTS:

Modern Carpentry, Unit 9

Guide To Residential Carpentry, Unit 18

THE NEXT LESSON IS: V-D-1(S)

"Lay Out and Cut Hip and/or Valley Rafters"

JOB SHEET
IN
ROOF FRAMING

V-B-1(J)

JOB: Lay Out and Cut Common Rafters

MATERIAL: 2" framing lumber as per plans and specifications

TOOLS AND EQUIPMENT: 25' steel measuring tape, framing square, marking pen or pencil, portable circular power saw, extension cord, saw horses (2)

GENERAL INFORMATION: The layout of common rafters with a framing square is based on the physical characteristics of the right triangle and is a practical application of geometry. The framing square is placed against the rafter in such a way that the tongue and body of the square form legs of a right triangle and the rafter top its hypotenuse. By setting 12" on body for the run, and a proportionate number of inches on the tongue for rise, we get a proportional length of rafter for each unit of 12" run which can easily be stepped-off by measuring 12" along the body and marking plumb lines along the tongue. Take your time and measure accurately.

PROCEDURE AND/OR TASKS: 1. V-B-1(TS), Make Wood Straightedge Clamp (Optional)
2. V-B-1a(TS), Select Rafter Material
3. V-B-1b(TS), Lay Out Common Rafter
4. V-B-1c(TS), Cut Common Rafter

CHECKING STANDARDS: 1. Material quality; grade
2. Rafter calculations; layout
3. Tool safety; operation
4. Rafter fit (pattern rafters)

TASK SHEET

V-B-1(TS)

TASK: Make Wood Straightedge Clamp (Optional)
JOB: Roof Framing/Rafter Layout
TRADE: Building Trades
TOOLS AND MATERIAL: 8" table saw, 1/4" electric drill with 1/4" twist drill, (2) 1/4-20N.C. x 1" lg. carriage bolts, (2) 1/4-20N.C. wing nuts, 1" x 2" x 30" lg. white oak

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Cut Slots	1. Through material width 2. Centered on material thickness 3. 14" long each end
2. Drill Holes	1. 1/4" diameter holes thru 2. Centered on width of board 3. Spaced 1" from end, 3" on center 4. Five holes each end
3. Install Clamp Screws	1. In holes a. From same side of plate b. One hole at-a-time each end 2. Tap heads firmly to seat shoulder each hole 3. Install wing nuts and leave assembled NOTE: Clamp screws may be adjusted to different holes to clamp straightedge at varying angles on framing square

TASK SHEET

V-B-1a(TS)

TASK: Select Common rafter Material
JOB: Roof Framing
TRADE: Building Trades
TOOLS AND MATERIALS: 25' steel measuring tape, framing square
TASK BREAKDOWN:

STEPS	KEY POINTS
1. Study Plans, Specifications	1. Determine material size, type, grade 2. Observe key roofing dimensions a. Rise, run, span, overhang if any b. Slope or pitch c. Rafter spacing d. Building length
2. Calculate Rafter Material Length	1. Read "length of common rafter per foot of run" a. On face side of framing square blade b. Below inch mark equal to "rise" in inches per unit run (12") 2. Multiply the unit length x the units of length (include overhang)
3. Select Material	1. Size, type, grade as per specifications a. To be straight, free of warp b. To be free of major flaws 2. Length - next standard length over calculated length

TASK SHEET

V-B-1b(TS)

TASK: Lay Out Common Rafter

JOB: Roof Framing

TRADE: Building Trades

TOOLS AND MATERIALS: Framing square, wood straightedge clamp (self-made), marking pen or pencil, 2" framing lumber as per plans and specifications

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Position Rafter Material	1. On one face 2. On saw horses 3. On other work surface convenient for layout
2. Set Rise and Run	1. On framing square 2. With a wood straightedge 3. Clamp diagonally across face 4. Edge nearest elbow to: a. 12" run, outside of body b. "Inches" rise, outside of blade
3. Position Straightedge and Framing Square	1. On rafter, with... 2. Straightedge flush against top edge of rafter 3. Elbow of square flat across face of rafter 4. Outside of tongue to top end of rafter
4. Lay Out Ridge Center	1. Hold straightedge and square in position 2. Mark plumb line 3. Outside of tongue
5. Lay Out Plumb Cut Line	1. With framing square still in position 2. Measure "1/2 ridge board thickness" a. From elbow of framing square b. Along level line outside of body 3. Mark point measured on face of rafter 4. Slide straightedge along rafter top edge a. In direction from top to bottom of rafter b. To align outside of tongue with point measured 5. Mark plumb cut line outside of tongue
6. Lay Out Odd Unit Run	1. Return framing square to position in step #4 2. Measure odd unit a. From elbow of framing square b. Along level line outside of body 3. Mark point measured on face of rafter 4. Slide straightedge along rafter top edge

STEPS	KEY POINTS
7. Lay Out Full Units Run	a. In direction of rafter tail b. To align outside of tongue with point measured 5. Mark odd unit plumb line outside of tongue 1. Measure full unit (12") a. With framing square still positioned b. From elbow of framing square c. Along level line outside of body 2. Mark point measured on face of rafter 3. Slide straightedge along rafter top edge a. In direction of rafter tail b. To align outside of tongue with point measured 4. Mark full unit plumb line outside of tongue 5. Repeat key points 7-1 thru 7-4 above for total rafter run
8. Lay Out Bird's-Mouth	1. Reposition framing square a. To last full unit layout b. Framing square body level c. 12" mark on building plumb line 2. Measure back 3 1/2" from 12" mark (width of wall plate) 3. Mark point measured 4. Slide straight edge along rafter top to align outside of tongue with point measured 5. Draw plumb line to bottom edge of rafter NOTE: This marks inside edge of seat or level cut for bird's-mouth 6. Slide straightedge along top edge of rafter a. To align the outside of framing square body b. With 3 1/2" mark at lower edge of rafter 7. Mark seat cut of bird's-mouth along outside edge of framing square
9. Lay Out rafter Tail	1. Position straightedge and framing square a. Straightedge to top edge of rafter b. Elbow of framing square across face of rafter c. Outside of tongue on building plumb line of rafter 2. Layout and mark units of run of rafter overhand similar as rafter length, steps #6 and 7

STEPS	KEY POINTS
10. Square Rafter Tail	1. Scribe line a. Parallel to rafter top b. Through vertex to bird's-mouth c. To intersect rafter tail plumb cut line 2. Slide straightedge along rafter top edge to align outside of body with intersection of rafter tail and scribed line 3. Mark level line outside of body square with rafter tail

TASK SHEET

V-B-1c(TS)

TASK: Cut Common Rafter

JOB: Roof Framing

TRADE: Building Trades

TOOLS AND MATERIALS: 6 1/2" min. portable circular power saw, saw horses or work bench convenient for cutting operations, extension cord

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Check/Adjust Saw Blade	1. Check blade a. Right type for job b. Sharp; clean c. Properly installed 1) right rotation 2) Arbor nut tight 2. Adjust blade a. Square with saw base b. For proper cutting depth - material thickness plus gullet depth of teeth
2. Check/Adjust Saw	1. Guard a. In place b. Operable 2. Housing, handles, base a. Clean, dry, good condition b. Adjustment lock screws/levers tight 3. Cord a. Clean, dry b. No physical damage (crimps, cuts, etc.)
3. Check Saw Electrical	1. Voltage/amperage source adequate 2. Connections/grounds proper 3. Extension cords appropriate size, rating, length
4. Position Saw Horses/Work Bench	1. In clean, dry area 2. Convenient for sawing rafters a. Clear of traffic, tools or equipment b. With room for movement c. Close to material storage; building area
5. Position Rafter Material	1. On saw horses or work bench 2. To rest solidly on work bench 3. With ends to be cut overhanging bench a. To clear saw cuts made b. To support material being cut

STEPS	KEY POINTS
6. Cut Rafter	<u>NOTE:</u> Practice safety in use and handling of portable power saws 1. Remove loose clothing, jewelry 2. Cover long hair, wear eye protectors 3. Check for shorts in saw a. Plug in cord with saw on bench b. Stroke body of saw with back of hand before picking up 4. Position saw to cut material a. With the guide mark at front of saw base on layout line b. With waste material to operator's right c. Cord positioned so not to become tangled during sawing 5. Start saw - allow to attain full cutting speed 6. Make saw cut a. Advance saw into wood b. Follow line with smooth push stroke c. Allow weight of saw to rest on rafter d. Guide saw through full cut

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

V-C-1(1)

SUBJECT: Gable End Frames and Extended Roof Rake

AIM: The student will be able to explain the proper procedure for installing gable end frames and roof rakes.

TEACHING AIDS: Transparencies I.ED.IV-18T
Information Sheet V-C-1(IS)
Frame model or mock-up (instructor prepared)

MATERIALS: None

REFERENCES: Wagner, Willis H., Modern Carpentry, Unit 9
Durbahn, W.W. and Sundberg, E.W., Fundamentals of Carpentry, Chpt. 9

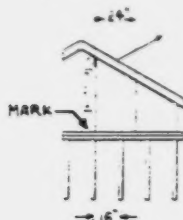
PREREQUISITE EXPERIENCE OF THE LEARNER: The student must have successfully completed previous informational lessons V-A-1(1) and V-B-1(1) and continue to display sincere interest in learning the building trades.

I. PREPARATION (OF THE LEARNER - MOTIVATION)

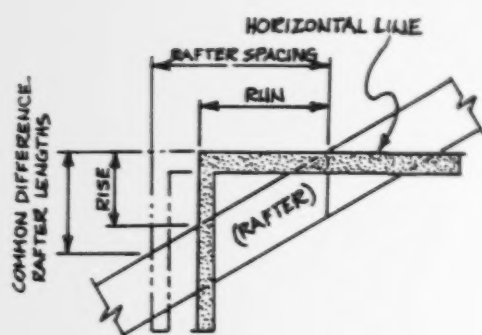
The gable end frame encloses the attic area of a gable roof at the end walls. It is the triangular section of the end wall above the top plates, formed by the rafter slopes, and may contain a ventilator or window. An extended roof rake is a means of extending the roof beyond the gable end walls to maintain the roof overhang on all sides of the building. There are several methods of framing gable end walls and extended roof rakes. The following lesson involves one of the more popular methods of each.

II. PRESENTATION (OF THE INFORMATION)

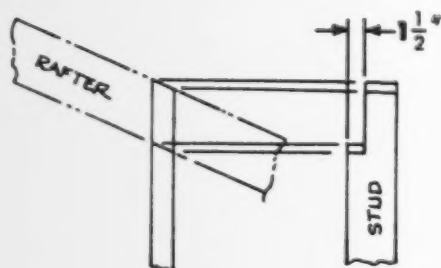
INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Gable End Frame	1. Triangular wall section 2. Above the plate line of end walls 3. Closes in attic area of a gable roof 4. May contain a ventilator or window 5. Consists of 2" x 4" gable-end studs a. Set vertically on the top plate b. Between top plate and end rafter c. Aligned with end wall studs
B. Locate Gable-End Studs on Top Plate	1. First stud a. Directly over the end wall stud b. Nearest a plumb line with the ridge c. Mark with a line squared on the double top plate d. Flush with edge of stud nearest center



C. Locate Gable-End Studs on Rafter



D. Gable End Stud Layout



2 x 4 GABLE-END STUD
NOTCHED TO RECEIVE RAFTER

2. Other studs
 - a. Locate from first stud
 - b. Spacing as per plans and details
 - c. Layout with framing square on top plate
 - c. Similar as regular studs on sole plate
 1. Position stud to first mark on top plate
 - a. Square to line
 - b. Flush to inside of rafter
 2. plumb with carpenter's level
 3. Mark line on rafter at inside edge of stud
- NOTE:** Mark lines on outside edge of stud at top and bottom of rafter for later use
4. Remove stud and position framing square
 - a. To inside of rafter
 - b. With body horizontal
 - c. With tongue down
 5. Set 12" (outside of body) on mark at top edge of rafter
 - a. Set "rise in inches" (outside of tongue)
 - b. Mark horizontal line on rafter at top edge of framing square
 6. Slide framing square along line to increase 12" (run) to stud spacing (16")
 7. Draw vertical line to outside of tongue - denotes location of next stud
 8. Read common difference at tongue, top edge of rafter
 9. Repeat key points 5, 6, 7 for each stud
 1. Stud marked in step "C" above; outside edge, top of rafter, constitutes longest gable-end stud
 2. Cut beveled end
 - a. Along beveled line marked at top of rafter
 - b. Square across stud width
- NOTE:** If the first gable-end stud on each side of the ridge center is the same distance from the center, the studs are equal length and may be cut to length in pairs
3. Notch upper end
 - a. 1 1/2" wide x rafter width (mark on edge of stud at bottom of rafter, step C)
 - b. To receive common rafter
 - c. To allow stud to stand flush with wall frame

4. Calculate the common difference in lengths
 - a. Difference in length is the difference in the rise a common rafter from one gable-end stud to the next
 - b. Difference depends on
 - 1) rise of the rafter
 - 2) spacing of gable-end studs

Example: $\frac{16'' \text{ stud spacing}}{12'' \text{ unit run}} = 1.33 \text{ units run}$

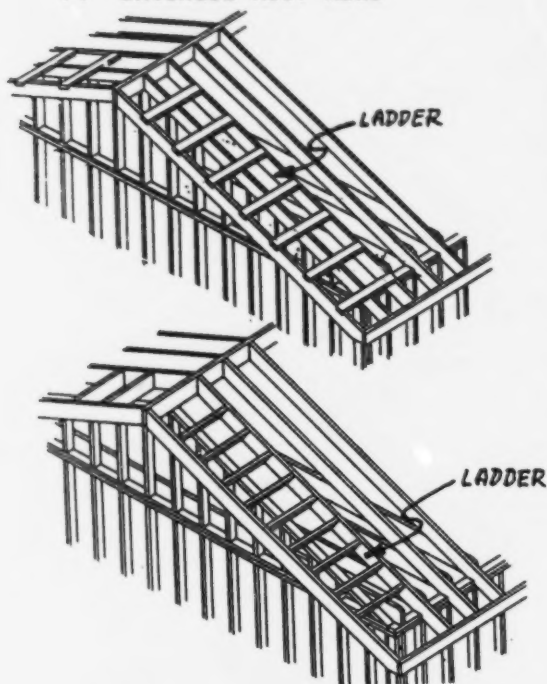
6" unit rise x 1.33 units run = 7.99", or 8" common difference

5. Use longest gable-end stud (each side) as a pattern rafter
 - a. Reduce each successive stud by the common difference
 - b. Cut bottom ends square

E. Install Gable-End Studs

1. One-at-a-time
2. To marks on double top plate
3. Square and plumb with wall frame
4. Toe nail to top plate
 - a. With (3) 10d nails
 - b. Similar to toe nailing wall studs to sole
5. Toe nail rafter to stud at notch
6. Face nail rafter to stud near top

F. Extended Roof Rake



1. Additional roof framework at ends of gable roof
2. Supports roof overhang at gable end walls
3. Consists of short frame members placed laterally (crosswise) to normal rafters
4. Extends over gable end walls
5. May be constructed several ways
6. Usually a ladder type construction
 - a. Using rafters as stringers
 - b. With steps straddling gable-end frame
7. Show example/illustration of different types gable-end roof rakes
8. Point out:
 - a. Position of laterals/cross members of ladder construction
 - b. Modified gable-end frame
9. Discuss construction procedure, nailing pattern

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS, OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

Simple Recall:

1. What is the common difference in lengths of gable-end studs spaced 16" O.C. for a 7 in 12 roof slope? 9.31" or 9 5/16"
2. What is the common difference in lengths of gable-end studs spaced 2'-0 O.C. for 1/3 pitch roof? 16"
3. A building 20'-0 wide has a gable roof that slopes 5 in 12. The longest gable end stud is 4'-2 1/2". What is the length of the next longest gable-end stud if spaced 16" O.C.? 3'-7 13/16"
4. A building 24'-0 wide has a gable roof with 1/4 pitch. The longest gable-end stud is 5'-8" long. What is the length of the next longest gable-end stud if spaced 24" O.C.? 4'-8"
5. A building 28'-0 wide has a gable roof with 1/4 pitch. the longest gable-end stud is 6'-8 1/2" . If the gable-end studs are spaced 16" O.C.
 - A. How many gable-end studs are required for the gable-end frame? 20
 - B. What is their common difference in their lengths? 7.98" 8"
 - C. How long is the shortest gable-end stud? 8 1/2"

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

True-False

- T 1. Gable-end walls close in the attic area of a gable roof.
- F 2. Gable-end walls generally run from sole plate to rafters.
- T 3. Gable-end frame consists of studs which rest on the top plate and extend to the rafter line at the roof.
- T 4. Gable-end studs may be spaced 24" O.C. over end wall studs spaced 16" O.C.
- F 5. No two gable-end studs in the same wall are the same length.
- T 6. No two gable-end studs in the same wall are the same.
- T 7. The common difference in the length of gable-end studs is based on the rise of the rafter and the spacing of the studs.
- T 8. The position of the first gable stud is located over the wall stud nearest in line with the ridge center.

- F 9. An extended roof rake supports the roof overhang of hip roofs.
- T 10. Gable-end studs are toenailed to top plates similar as regular studs are to sole plates.
- F 11. As gable-end studs are placed a slight crown should be forced into the end rafter to quarantine tightness.
- F 12. The common difference of length for gable-end studs spaced 2'-0 O.C. for 1/4 pitch roof is 9".

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

A gable end frame encloses the attic area of a gable roof at its end walls. It is the triangular wall section between the top plates and end rafters and is composed mostly of gable-end studs set on the top plates, in line and spaced with regular wall studs.

Gable end studs (all) extend to the top of the rafter and are bevel cut flush with the top of the rafter which is sloped. In addition the outside edge is notched on the same bevel to receive the rafter and allow the stud to stand flush with outside of the other wall frame members.

To locate gable-end studs, square a line across the top plate aligned with the inside of the wall stud nearest the ridge center. Layout the other stud locations on the top plate as per dimensions -- use framing square similar to stud layout on sole plates.

To determine gable-end stud lengths, position a stud at the first mark on top plate (line closest ridge center) and plumb the stud against the inside of the rafter. Mark a line across the outside edge of the stud at the top of the rafter; mark a line across the outside edge at the bottom of the rafter. The line across the top of the rafter marks the length of the longest gable-end stud. The line across the bottom of the rafter marks the length of the notch. The rafter length and notch should be cut to these beveled lines square to the rafter width, the notch being cut the depth of the rafter thickness (1 1/2"). Gable studs, each gable end side, will have identical top.

Calculate the common difference in lengths of gable-end studs by multiplying the unit rise of the rafter in "inches" x the spacing of the studs in units of run (12"). If the stud spacing is 16" O.C. divide spacing (inches) by unit run (inches), multiply result by unit rise (inches) = common difference in lengths.

Example: $16 \div 12 = 1.33 \times 6 = 7.98$ or 8" common difference

Subtract the common difference from the longest gable-end stud for the next stud and stud in descending length thereafter.

To install gable-end studs position stud to appropriate line on the top plate and plumb with carpenter's level. Toenail to top plate similar as regular studs. Toenail and face nail rafter to stud at top while holding in place. Exercise care not to force a crown in the rafter during stud installation.

SUGGESTED READING FOR STUDENTS:

Modern Carpentry, Unit 9

Framing, Sheathing and Insulation, Unit 15

Fundamentals of Carpentry, Chapter 5

THE NEXT LESSON IS: V-D-1(I), "Hip and Valley Rafters"

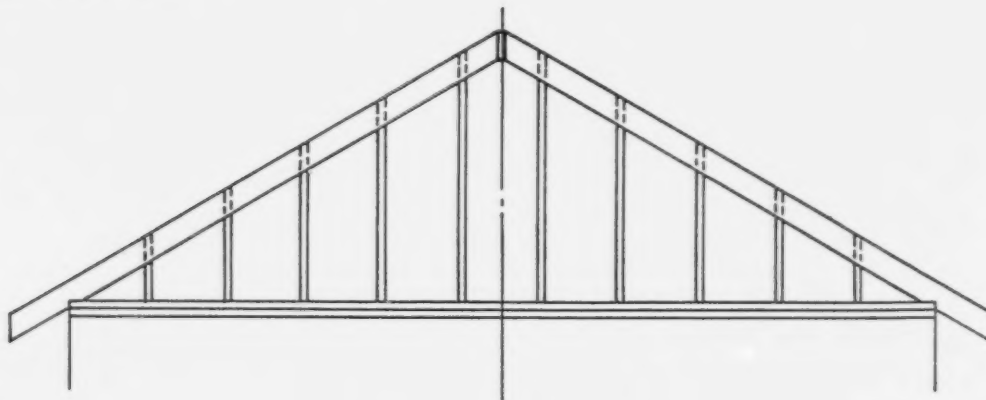
INFORMATION SHEET
ON
ROOF FRAMING

V-C-1 (IS)

SUBJECT: Gable End Frames

INTRODUCTORY
INFORMATION:

Gable end frames enclose the attic area of gable roofs at the end walls. They are the triangular wall sections above the plate line that extend to the roof/rafter lines. Gable end frames are generally constructed of 2" x 4" studs cut to fit the sloping end rafter, and mounted on the top plate spaced and aligned with the regular wall studs. Gable end frame may contain a ventilator or window lite.

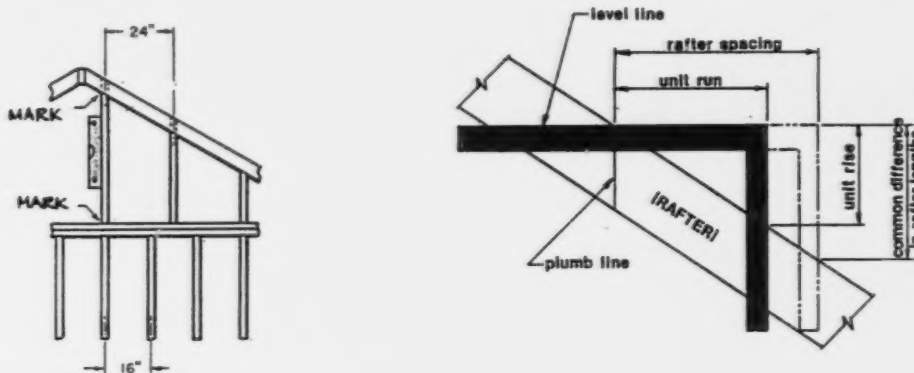


GABLE END FRAME

GENERAL INFORMATION:

The position of the first gable-end stud is directly over the regular wall stud nearest the center of the ridge. To locate this stud, make a mark on the top plate square, in line, and flush with the inside edge of the regular wall stud. Other gable-end studs can then be laid out on the top plate with the framing square using stud spacing similar to wall stud layout on the sole plate. (Notice that if the first gable-end stud either side of the ridge center is equal distance from the center, the studs are equal length, and therefore may be cut to length in pairs.) To locate the studs on the end rafter, position first stud to its mark and plumb it against the inside of the rafter with a carpenter's level. Mark the rafter with a plumb line to the inside of the stud. Remove the stud and position a framing square against the inside of the rafter with blade horizontal and the tongue down. Set 12" (unit run) on the body to the plumb mark at the top edge of the rafter and the "unit rise in inches" on the tongue to the top edge of the rafter. Draw a level line along the top of the body. Slide the framing square

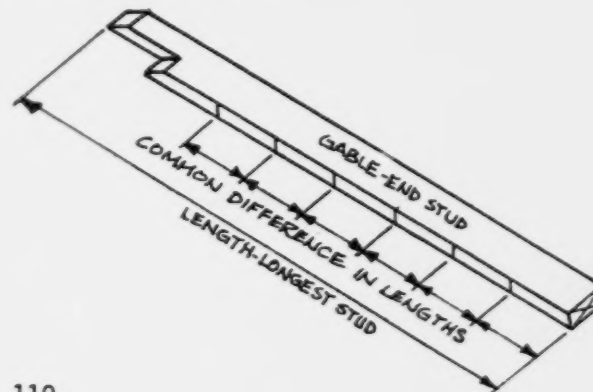
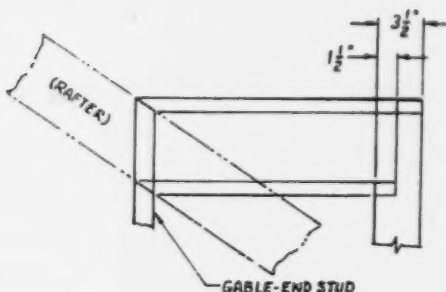
blade along this level line until the inch mark of the stud spacing on the outside of the body is aligned with the plumb line at the top edge of the rafter. Draw a plumb line on the rafter to the outside of the tongue. At the same time read the dimension on the outside of the tongue at the top of the rafter. This marks the location for the inside of the next stud on the rafter and gives you the difference in the lengths of the two studs. This is also the common difference of each successive stud.



The common difference in stud lengths can also be readily calculated simply by multiplying the unit rise of the rafter times the stud spacing in terms of units of run of the rafter.

Example: $16'' \text{ (spacing)} \div 12'' \text{ (unit of run)} = 1.33 \text{ units of run}$
 $8'' \text{ unit rise} \times 1.33 \text{ units of run} = 10.64''$, or $10 \frac{5}{8}''$ common difference

To layout gable-end studs position a stud to the first mark on the top plate nearest the ridge center. Plumb the stud flush to the inside of the end rafter using a carpenter's level. Hold the stud in position and mark a line across the outside edge of the stud at the top of the rafter; at the bottom of the rafter. The line drawn at the top of the rafter marks its length -- longest of the gable end studs. The line drawn at the bottom of the rafter marks the notch in which the end rafter will fit.



Layout and cut the longest gable-end stud. Check the stud for fit. If the stud fits mark the common difference in lengths of studs and use it as a pattern to select material lengths and make the other studs on that side of the gable end wall. If the first gable-end stud on each side of the ridge center is equal distance from the center the gable-end studs are equal in length, therefore may be cut to length in pairs for the opposite sides and the notch placed to the opposite side of one for fit. If the first stud each side differs in spacing from the ridge center, each side must be laid out separately.

To install gable-end studs, position stud to the proper mark on the top plate and plumb flush with the wall line. Toenail to the top plate with 10d common nails similar to installing regular studs on the sole plate. Toenail the end rafter at the bottom centered with the stud at the notch; face nail the rafter at the stud near the top.

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

V-D-1(I)

SUBJECT: Hip and Valley Rafters

AIM: The student will be able to lay out and cut hip and/or valley rafters to properly fit in the roof frame.

TEACHING AIDS: Information Sheet V-D-1(IS), "Hip/Valley Rafters"
Assignment Sheet V-D-1(AS), "Sizing Hip/Valley Rafters"
Chalkboard

MATERIALS: Chalk

REFERENCES: Wagner, Willis H., Modern Carpentry, Unit 9
Feirer, John L. and Hutchings, Gilbert R., Guide to Residential Carpentry, Unit 19

PREREQUISITE EXPERIENCE OF THE LEARNER: The student must have successfully completed all previous informational lessons in Major Block V, "Roof Framing". The students must continue to display sincere interest in learning the building trades.

I. PREPARATION (OF THE LEARNER - MOTIVATION)

A hip rafter is a roof member which extends from an outside building corner diagonally to the roof ridge. It forms a raised area or "hip" which is the line of intersection between adjacent roof slopes.

A valley rafter is a similar roof member except that it extends from an inside building corner to the roof ridge and forms a depressed area or valley which is also a line of intersection for adjacent roof slopes.

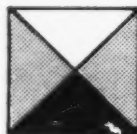
The length of a hip or valley rafter, like the length of a common rafter, is calculated on the basis of the unit run and unit rise and/or total run and total rise. Both hip and valley rafters have the same total rise as common rafters of the same roof. However, since hip and valley rafters run 45° diagonal to common rafters, their run is based on a 45° diagonal to the common rafters run. Keeping this in mind, and the fact that the plumb cuts and level cuts joining hip/valley rafters to the ridge board and top plates differ from that of common rafters, these rafter lay outs are not difficult.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Hip Roof/Rafter	- Sheds water four directions - Both sides (like gable roof) - Both ends - May, may not have ridge line (board) - Rectangular - Square - Roof slopes intersect to form raised area or "hip" - Hip slopes diagonally 45° from outside building corner to roof ridge

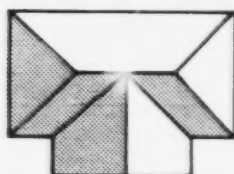


A

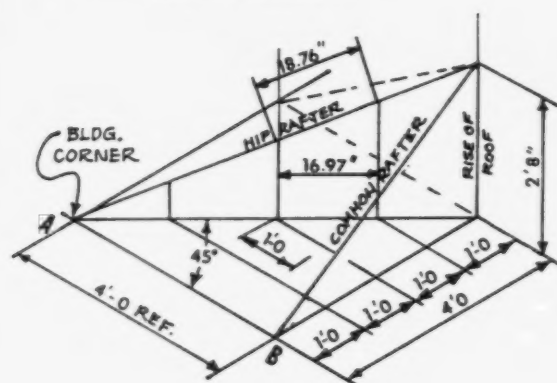


B

B. Valley Roof/Rafter



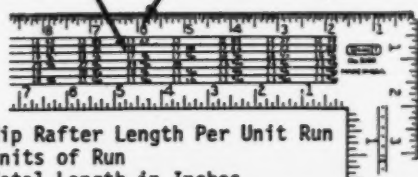
C. Hip/Valley Rafter Calculations



D. Hip Rafter Length (Theoretic)

1. Rafter Tables

Rafter Length Per Unit Run Inch Number Also Unit Rise



18" Hip Rafter Length Per Unit Run
10 Units of Run
180" Total Length in Inches
 $180" \div 12 = 15'-0"$ Length of Hip Rafter

EXAMPLE

5. Hip rafter main roof frame member for hip
6. Hip jack rafters run:
 - a. Parallel and normal with common rafters
 - b. From wall top plates to hip rafters
1. Also sheds water four directions
2. May be combined with gable or hip roof
3. Roof slopes intersect to form a depressed area or "valley"
4. Valley slopes diagonally 45° from inside building corner to roof ridge
5. Valley rafter main roof frame member for valley
6. Valley jack rafters run
 - a. Parallel and normal to common rafters
 - b. From ridge board to valley rafters
1. Are based on the physical characteristics of the right triangle
2. Basis is unit rise and unit run, or total rise and total run
3. Rise is the same for both hip rafter and common rafter, in the same roof frame
4. Run of the hip rafter is at a 45° diagonal to the run of the common rafter
5. Number of units of run of a hip rafter are the same as the common rafter
6. Lengths of the "units of run" differ
 - a. Unit run of common rafter is 12" (standard)
 - b. Unit run of hip rafter is the square root of $12^2 + 12^2$, or 16.97 (Pythagorean's theorem)
7. Total run is no. of units x 16.97, or 17"
1. May be determined with rafter tables and mathematical calculations
2. May be laid out using framing square and step-off method
1. On face of framing square
2. Locate inch mark
 - a. On outside of body
 - b. That corresponds "inches rise" per unit run
3. Read "length of hip rafter per foot of run"
 - a. On second line
 - b. Below inch mark

2. Book of Rafter Lengths and Roof Construction

4. Multiply length x total units of run, common rafter
 5. Convert decimal inches to feet and inches
- Example: Building span 20'-0, Hip roof, 6/12 slope (See Example)

1. Find tables "Width of Building" (near back)
 2. Find desired building width
 3. Note column "hip" rafter lengths
 4. Align inch rise with rafter length
 5. Read appropriate rafter length
- NOTE: Allow additional length for rafter tail and/or plumb cuts

E. Lay Out (Step-off Method)

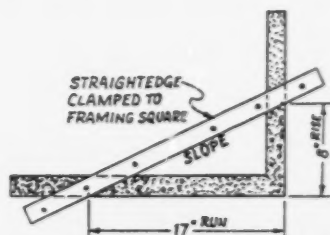
1. Determine Rafter Length

1. Is very similar that of common rafter
2. Also requires use of framing square
1. Use rafter tables
2. On face of framing square
3. Find inch number on scale
 - a. Outside edge of body
 - b. That corresponds with inches rise per foot run
4. Read length - Hip or Valley Rafter per foot of run
 - a. On second line of table
 - b. Directly under inch number equal to inches rise
5. Multiply length x no. of units of common rafter
6. Convert decimal feet to feet and inches

2. Select Rafter Material

1. Length based on calculations above
- NOTE: Calculated lengths are theoretic and do not include overhang. Material allowance should be provided for rafter tails
2. Size based on rafter span, spacing, slope, and roof loads - refer to chart "Max Span for Rafters", V-B-1(1S)
 3. To be straight, free of major flaws
 4. First piece to be used as a pattern rafter

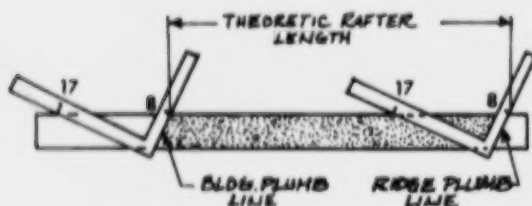
3. Set Rise and Run



1. On the framing square
2. With wood straightedge clamped diagonally across the face
 - a. Straightedge to 17" (16.97") mark; "run" on outside of the body
 - b. Same edge to inch mark, "rise" on outside of the tongue

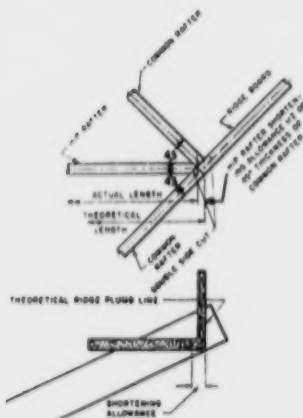
NOTE: Illustrate on the chalkboard

4. Lay Out Rafter Length Theoretic



1. Position rafter material for layout
 - a. Horizontally on one face
 - b. On saw horses, other convenient surface
2. Position framing square and straight-edge
 - a. On top edge of rafter
 - b. At top end of rafter
 - c. With elbow of framing square across face of rafter
3. Mark ridge plumb line (theoretic center of ridge)
 - a. Along outside edge of tongue
 - b. On face of rafter
4. Step-off rafter length in units of run
 - a. Using framing square and straight-edge
 - b. Slide along top edge of rafter
 - c. Mark units of 17" run
 - d. Similar as for common rafters, or...
5. Measure calculated rafter length
 - a. From top of ridge plumb line
 - b. Along top edge of hip rafter
6. Mark building plumb line
 - a. At length measured opposite end
 - b. Similar and parallel to ridge plumb line

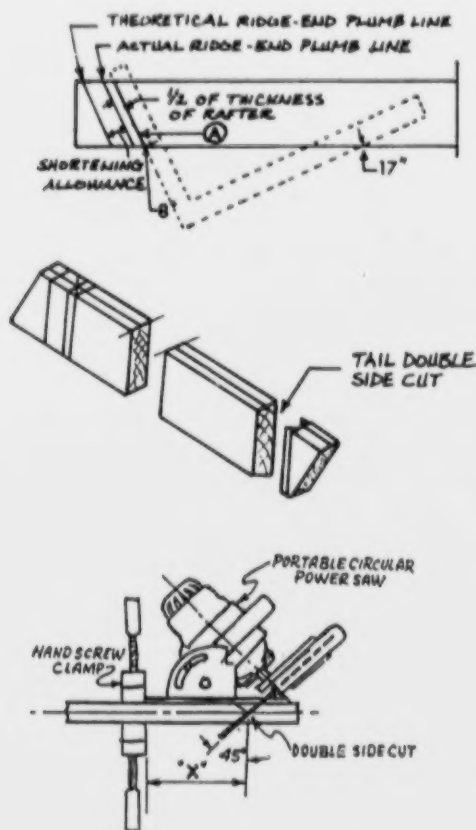
5. Ridge Allowance



1. Is the shortening of the rafter theoretic length
2. Is allowance for ridge board
3. Amounts to one-half the horizontal thickness of the ridge at the point where the rafter connects
4. On hip rafter this amounts to one-half the 45° thickness or 1 1/16"
5. Measured along horizontal run of rafter
6. To lay out:
 - a. Place tongue of square on ridge plumb line
 - b. Measure allowance along body of square
 - c. Slide framing square down to align tongue with point measured
 - d. Draw "rafter plumb cut" line

6. Side Cuts

1. Allow hip rafter to fit between common rafter
2. Are taken from the center of the hip rafter thickness
3. 45° to each side
4. Parallel to plumb cut line
5. To lay out side cuts for hand sawing
 - a. Place tongue of framing square along ridge plumb cut line



7. Bird's-mouth

- b. Measure one-half thickness of hip rafter along body (level line); mark
- c. Slide straightedge and square to align tongue with mark - draw bevel line
- d. Turn rafter on edge - draw edge centerline
- e. Square line across top with bevel line
- f. Connect center-at-plumb cut with edges-at-bevel line - mark side cuts

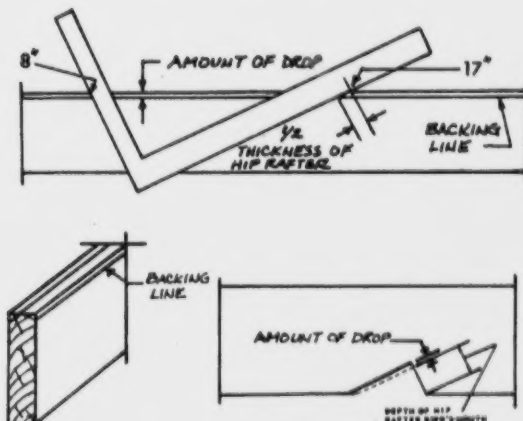
NOTE: The rafter tail is laid out similarly but in the opposite direction

5. To make double side cuts with a portable circular power saw:

- a. Mark edge center on scrap 2 x 6
- b. Set hand screw clamp square on 2 x 6
- c. Make double side cut 45° using clamp as guide for saw base of portable power saw
- d. Verify dimension "X"; intersection of saw cuts to edge of clamp (guide for saw)
- e. Draw guide line on face of rafter parallel to, and "X" distance from, plumb cut line
- f. Position clamp on hip rafter and make double side cuts on hip rafter using clamp as a guide

1. Very similar to bird's-mouth of common rafter
2. Both have same function, similar appearance
3. Differ in that hip rafter:
 - a. Forms lower angle with horizontal therefore level cuts are longer
 - b. Spans greater distance requiring wider material therefore plumb cuts are deeper
4. Alike in that vertical rafter thickness above heel cut at plumb line is the same
5. To lay out a bird's-mouth on a hip rafter
 - a. Measure the vertical thickness above bird's-mouth at building plumb line on common rafter
 - b. Measure down along building plumb line of hip rafter layout
 1. from top edge of hip rafter
 2. same dimension as on common rafter

8. Backin or Dropping Hip Rafter



9. Overhang

3. mark point measured on plumb line
- c. Position framing square and straight-edge on hip rafter
- d. Mark seat cut; mark heel cut
1. Necessary when dimension above bird's-mouth exactly the same on hip rafter as common rafter
 - a. Edges of hip rafter will extend above upper ends of jack rafters
 - b. Interferes with proper application of sheathing
2. Backing means to bevel the upper edges of the hip rafter
3. Dropping means to deepen the bird's-mouth to bring the top edge of the hip rafter down to the upper ends of the jacks
4. To layout amount of bevel or drop:
 - a. Set framing square to the cut of the rafter (rise and run) along top edge
 - b. Measure one-half the rafter thickness from the top edge along the blade
 - c. Draw line parallel to top edge through point measured

NOTE: This line is the depth of the bevel for backing, or the additional depth of bird's-mouth for dropping

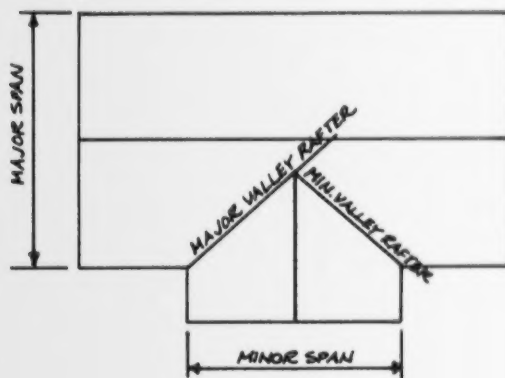
1. Of hip rafter is at 45° diagonal to overhang of common rafters
2. Is the hypotenuse of a right triangle whose shorter sides equal run of common rafter
3. To determine length of rafter tail:
 - a. Find unit length of hip/valley rafter - see step #1 this lesson
 - b. Multiply the unit length of hip/valley rafter X the "run" of common rafter overhang

Example: Common rafter overhang is 1'-6" for a roof with an 8" unit rise

18.76"	unit length of hip/valley rafter
x 1.5	units of run common rafter
28.14"	length of rafter tail - 2'-4 1/8"

4. Lay out 2'-4 1/8" additional length
 - a. Along top edge of hip/valley rafter
 - b. From building plumb line to rafter tail
5. Mark rafter tail plumb line

10. Valley Rafters



6. Lay out rafter tail double side cuts similar to ridge double side cuts but in opposite direction
1. Length calculations are the same as hip rafter
2. Ridge plumb cut and side cuts are the same as hip rafter
3. Bird's-mouth lay out is same as hip rafter
 - a. Valley rafter does not need additional depth in bird's-mouth for dropping
 - b. Heel plumb cut requires side cuts for fit just as ridge plumb cut
4. Tail has a double side cut but in reverse for fascia boards to fit
5. For unequal roof spans
 - a. One valley rafter laid out to major span
 - b. One valley rafter laid out to minor span
 (Illustrate on chalkboard)

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS, OR ASSIGNMENT, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

Instructor: Passout Assignment Sheet V-D-1(AS)
Discuss assignment instruction with students

Students: Complete assignment as per instructions
Submit to instructor for grade

IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

Simple Recall:

1. The run of a hip rafter is the hypotenuse of a right triangle whose shorter sides are equal to _____. the run of the common rafter
2. A unit of run of a hip or valley rafter is _____ long. 17"
3. Hip/valley rafters run at a _____° diagonal to common rafters. 45°
4. The ridge allowance for a hip or valley rafter is _____. 1/2 of 45° thickness of common rafter

IV. VERIFICATION (CON'T)

V-D-1(I)

- | | |
|--|----------------------|
| 5. A hip rafter has a rise of 8'-0 and a run of 17'-0. The roof pitch is ____. | <u>1/3</u> |
| 6. The unit length of a hip rafter is 17.69. If the building span is 20'-0, what is the length of the hip rafter in feet and inches? | <u>14'-9"</u> |
| 7. The bevel cuts at the ridge plumb line and tail plumb line are for fit are called ____. | <u>side cuts</u> |
| 8. The mathematical principle which is the basis for rafter calculations is called ____ Theorem. | <u>Pythagorean's</u> |
| 9. A vertical line or cut on a rafter in its proper position is called a/an ____ line or cut. | <u>plumb</u> |
| 10. Rafter material size is based on its span, spacing, slope, and ____. | <u>roof loads</u> |

V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

Hip and valley roofs shed water in four directions; to the ends as well as the sides. Hip and valley rafters form intersections for these roof slopes as they extend diagonally 45° from the building corners to the roof ridge. Hip rafters run from outside corners and present a raised area or "hip" while valley rafters run from inside corners and present a depressed area or valley.

The length of hip/valley rafters, like the length of common rafters, is calculated on the basis of the physical properties of a right triangle and Pythagorean's Theorem which states, "the square of the hypotenuse (rafter) is equal to the sum of the square of the two shorter legs (horizontal run of rafter and vertical rise of rafter). Hip and valley rafters have the same vertical rise as common rafters in the same roof. Hip and valley rafters have the same number of units of run as a common rafter in the same roof (a unit of run of a common rafter is 12"). However, since hip/valley rafters run at 45° diagonal to common rafters, the run of hip rafter is also a 45° diagonal of common rafter. Again, using Pythagorean's Theorem, the run of a hip or valley rafter computes to 16.97 taken as 17". With this in mind lay out of hip/valley rafters using framing square is similar to that of common rafters except instead of 12" unit run, use 17" unit run.

The plumb cut at the ridge board must also allow for the 45° diagonal to which hip and valley rafters are set. Instead of 1/2 the thickness of the ridge board as with common rafters, it is 1/2 the 45° thickness of the ridge board and/or common rafter. This dimension is taken along the horizontal run and computes to 1 1/16". In addition, side cuts must be made so that the hip rafter will fit between the upper ends of the common rafters at the ridge board. Side cuts are made 45° each side of the edge centerline of hip/valley rafters and normal to the ridge plumb cut.

The bird's-mouth of a hip or valley rafter is laid out similar to that of a common rafter with a heel cut flush to the building plumb line and a level cut for the rafter to set squarely and solidly on the wall plate. The big difference is that the plumb and level cuts are generally deeper/longer because the rafter is heavier and has lower angle with horizontal and - the rafter thickness above the bird's-mouth, at the building plumb line, must be maintained with that of common rafters. In addition, valley rafter heel cuts should include side cuts similar to those at the ridge to fit the inside corners at the plates. Hip rafters may require an additional drop to bring the top edges down in line with the ends of the hip jacks. The amount of drop is calculated and taken from the level cut of the bird's-mouth.

Hip/valley rafter tails are calculated and laid out just as the rafter. When boxed in by a cornice the tail plumb cuts must include side cuts for connecting fascia. The direction of cuts depends on whether it is a hip or a valley, and outside or an inside corner fascia board. The side cuts are still 45° through 1/2 the rafter thickness, parallel to the tail plumb cut.

SUGGESTED READING FOR STUDENTS:

Information Sheet V-D-1(IS), "Hip/Valley Rafters"
Modern Carpentry, Unit 9, Roof Framing
Framing Sheathing and Insulation, Unit 16, Hip and Valley Rafters

THE NEXT LESSON IS: V-D-2(I), "Jack Rafters"

INFORMATION SHEET
ON
ROOF FRAMING

V-D-1 (IS)

SUBJECT: Hip and Valley Rafters

INTRODUCTORY
INFORMATION:

A hip rafter is a roof member which extends from an outside building corner diagonally to the roof ridge. It forms a raised area or "hip" which is the line of intersection between adjacent roof slopes.

A valley rafter is a similar roof member except that it extends from an inside building corner diagonally to the roof ridge and forms a depressed area or valley which is also a line of intersection for adjacent roof slopes. The length of a hip/valley rafter, like the length of a common rafter, is calculated on the basis of the unit rise and the unit run, and/or the total rise and the total run. The same method used to calculate common rafter lengths can be used to calculate hip/valley rafter lengths, however, some of the data used in the calculations will be different.

GENERAL INFORMATION:

The total rise of hip and valley rafters is the same as that of the common rafters in the same roof. However hip and valley rafters form 45° angles with the building lines therefore the run of a hip or valley rafter is a 45° diagonal to the run of a common rafter, or... the hypotenuse of a right triangle whose two shorter legs each equal the run of a common rafter.

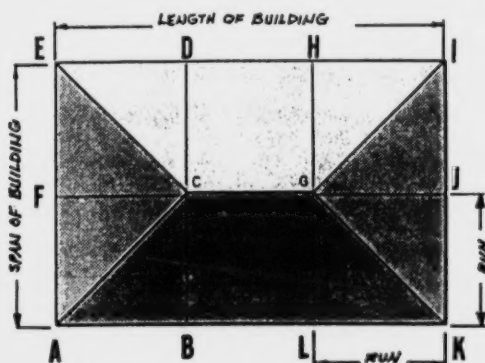


FIG. 1 ROOF PLAN

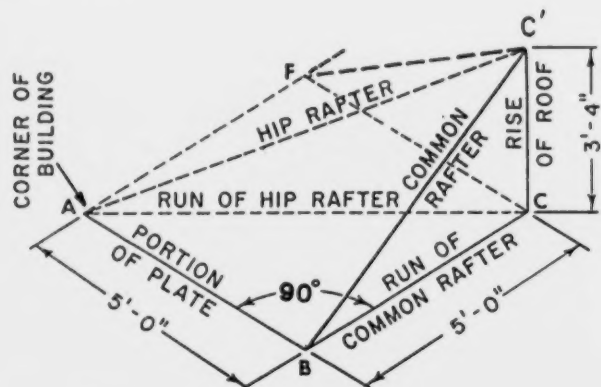


FIG. 2 PERSPECTIVE SHOWING RELATIVE POSITION OF
HIP RAFTERS TO COMMON RAFTERS

In the roof plan (Fig. A), lines EC, AC, KG, and IG form 45° angles with the building lines. These lines, which indicate a hip in the roof plan, correspond

to the total run (not length) of the rafter it represents. It is evident that the total run of a hip rafter is the hypotenuse of a right triangle whose shorter legs are each equal to the total run of a common rafter. Reference rafter AC; triangle ABC.

Since the unit of run for a common rafter is 12", the unit run of a hip or valley is the 45° diagonal of 12"; or, the diagonal of a 12" rise on a 12" run. This can be looked on a rafter tables just like a common rafter with a 12" rise. The unit run of a hip or valley rafter is 16.97".

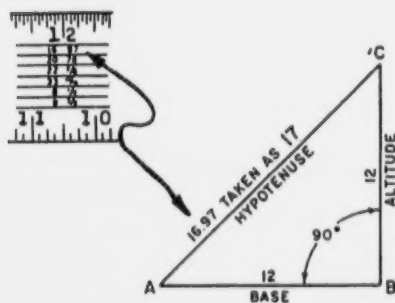


FIG.3 THE HYPOTENUSE OF A RIGHT TRIANGLE WHOSE SHORTER SIDES EACH EQUAL 12" IS 16.97".

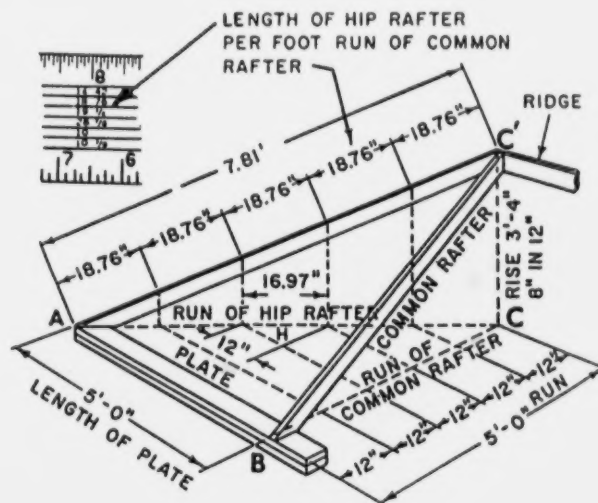


FIG.4 SHOWS RELATIONSHIP BETWEEN A UNIT OF RUN OF A COMMON RAFTER AND A HIP RAFTER

Hip/valley rafter lengths can be readily calculated using the rafter tables on the face of the framing square. On the blade look under the inch mark which corresponds to inches rise of the rafter. Read second line, "Length of Hip or Valley Per Foot Run". Multiply "length per foot run" x "number of units common rafter". Example: (See Fig. 4) 8" rise = 18.76" length per unit

$$\begin{array}{r} \text{x 5 units} \\ 18.76 \times 5 = 93.80 \end{array}$$

12)93.80 (7.81' or 7'-9 13/16")

Using 16.97" as the unit of run, 17" on the blade of a framing square, and the same unit rise as the common rafters, hip/valley rafters can be laid out using the step-off method just as common rafters. They can also be laid out by measur-

ing their calculated length along the rafters top edge and properly drawing plumb lines at the ridge center, building line, and rafter tail, if any. This can be done with the framing square and/or the speed square. It should be noted that rafter lengths, both common and hip or valley; with rises from 1" to 12" and building widths to 40'-0", can be looked up in Swanson's Book of Rafter Lengths. (see Fig. 5, below)

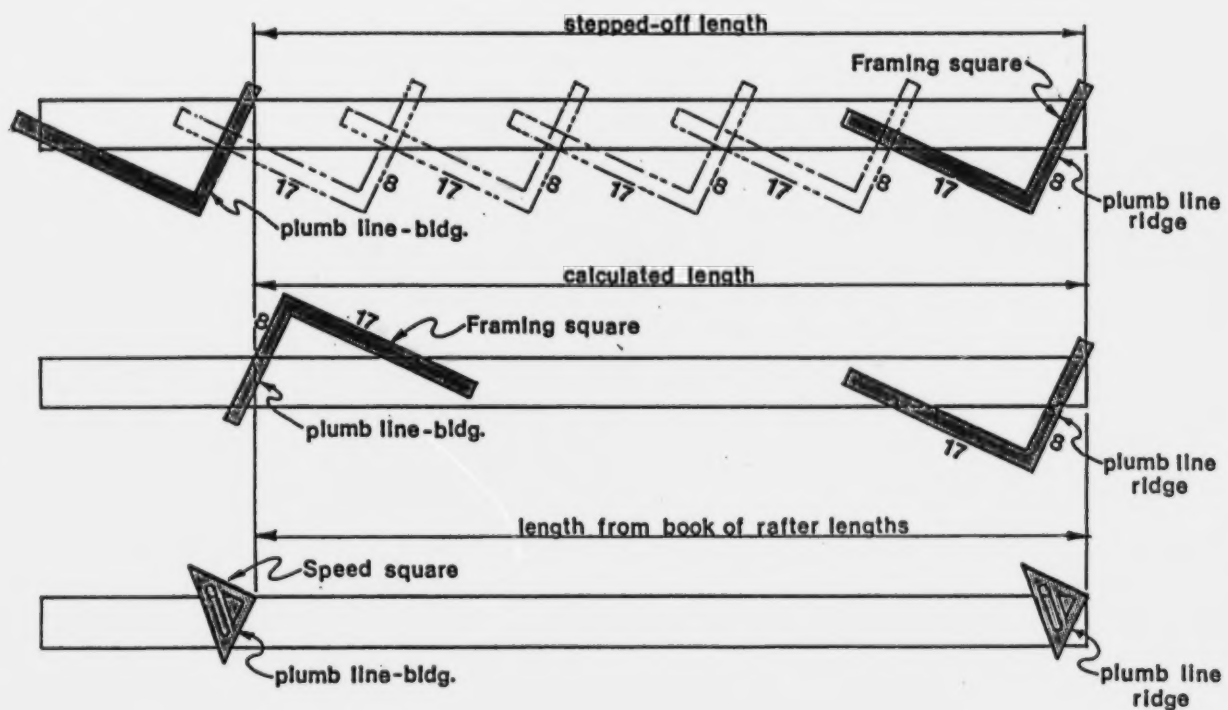


FIG. 5 THREE METHODS TO LAYOUT HIP RAFTER

As in the case with the common rafter, the length layed out is theoretical length of a hip or valley rafter and does not take into consideration allowance for the ridge board. On common rafters, it is $\frac{1}{2}$ the ridge thickness taken along the rafter run as common rafters are square to the ridge board. However, hip and valley rafters are at a 45° diagonal to the ridge board, therefore the ridge allowance would have to be $\frac{1}{2}$ of the 45° thickness of the ridge board and/or common rafter taken along the run of the hip/valley rafter (Fig. 6). In addition to the plumb cut, hip and valley rafters must have what is known as side cuts, in order to fit flush and plumb between the common rafters which join at the same theoretic point on the ridge. Side cuts are made 45° each side of the rafter edge center and parallel to the plumb cut.

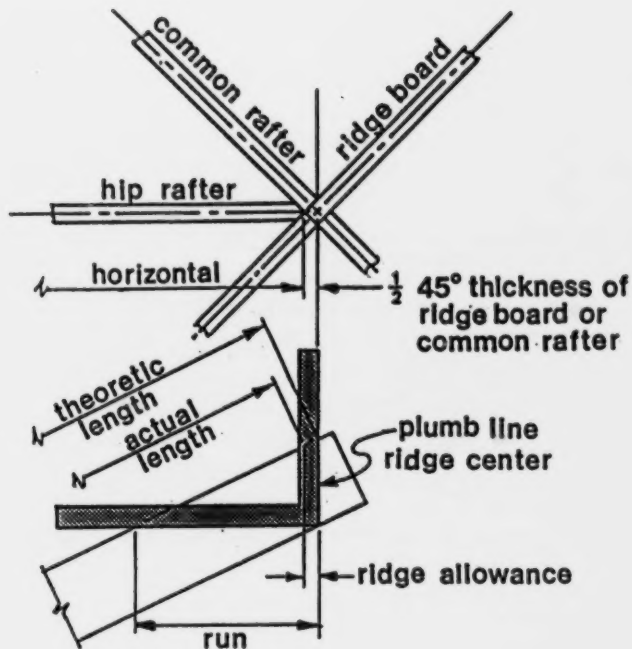


FIG. 6

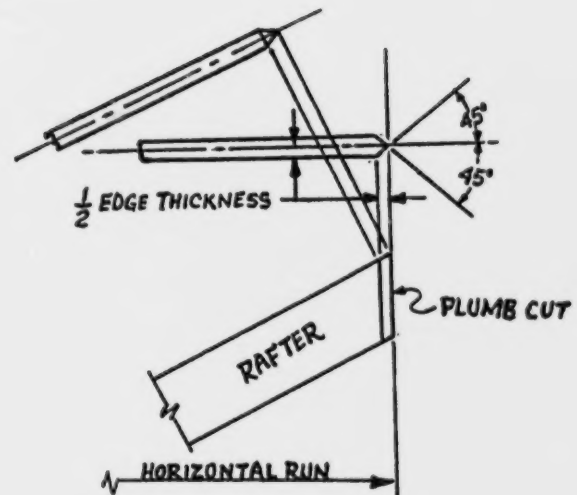


FIG. 7

Side cuts are easiest made with a portable power circular saw. (Fig. 7)

Test side cuts:

1. Adjust portable power saw to cut 45° through a 1 1/2" thickness
2. Clamp hand screw clamp squarely to scrap 2 x 6 approximately 8" from end
3. Make 45° cuts both sides using edge of clamp as saw base guide
4. Check cuts to intersect at center of edge of material; check distance from intersection of cuts to edge of clamp guide

Make side cuts:

1. Lay out dimension "from intersection of cuts to edge of clamp guide" on face of rafter, from plumb cut (line)
2. Draw line through point measured parallel to plumb cut (line). Clamp guide edge of hand screw clamp to line
3. Make side cuts with portable power circular saw using clamp as the saw base guide

To lay out side cuts for hand sawing:

1. Place tongue of framing square along ridge plumb cut (line) and measure one-half thickness of hip rafter along the body (rafter run). Mark!
2. Adjust framing square to align tongue with mark and parallel to plumb cut (line). Draw parallel line (edge of bevel) on rafter face
3. Turn rafter top edge up! Square a line across top, aligned with bevel line on side; draw edge center line
4. Connect center-at-plumb cut with edges-at-bevel. Marks side cuts for hand sawing

Side cuts are also used on the heel cut of bird's-mouth for valley rafters and at the tail cuts of both hip and valley rafters where fascia boards are applied. These side cuts may be in the opposite direction but their principle of lay out is the same and should be mastered by the framing carpenter.

The function of the bird's-mouth on hip and valley rafters is the same as the function of the bird's-mouth on common rafters. The only difference is, that since hip/valley rafters are longer, heavier, and form a lower angle with the horizontal, the bird's-mouth cuts are longer and deeper making it bigger. (Fig. 8)

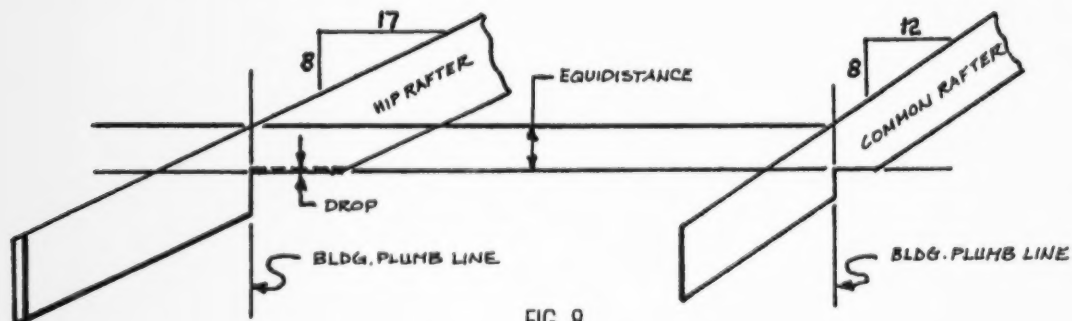


FIG. 8

The location of the bird's-mouth is controlled by the length of the rafter which establishes a building plumb line - also the heel cut of the bird's-mouth. But the depth of the bird's-mouth is determined by the thickness of the common rafter above the bird's-mouth at the building line. This dimension must be maintained for roof decking to lay flat on all rafters.

To lay out a bird's-mouth on a hip/valley rafter:

1. Measure vertical distance "top of rafter to bird's-mouth" along building plumb line of common rafter
2. Lay out and mark identical distance along building plumb line of hip/valley rafter
3. Position framing square to plumb line, through mark - draw level line (cut)

When the dimensions above the bird's-mouth are exactly the same on hip rafters as on common rafters, the edges of the hip rafter will extend above the upper ends of the jack rafters. This may cause interference with the proper application of sheathing. To remedy this the hip rafter should either be backed (beveled both edges on top) or dropped slightly to bring the top edge down to the upper ends of the jacks, Fig. 9.

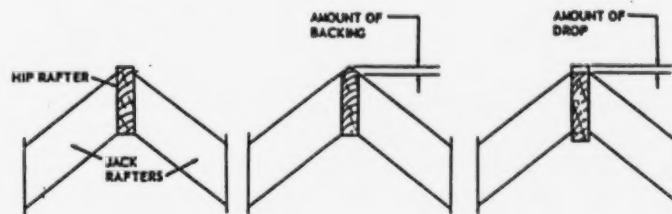


FIG. 9

To lay out the amount of bevel or drop:

1. Set the framing square to the cut of the rafter (rise and run) along its top edge
2. Measure one-half the rafter thickness from the top edge along the blade - mark point measured
3. Draw a line through the point measured parallel to the top edge, Fig. 10

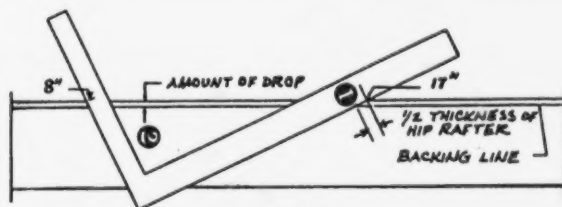


FIG. 10

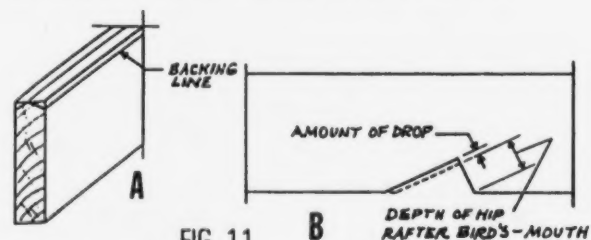


FIG. 11

This line is the depth of the bevels for backing a hip rafter (Fig. 11-A), or... the additional depth of the bird's-mouth required to properly drop the hip rafter.

ASSIGNMENT SHEET
IN
ROOF FRAMING

V-D-1 (AS)
KEY

SUBJECT: Sizing Hip/Valley Rafters

AIM: The student will be able to determine hip and/or valley rafter lengths and make appropriate material size selections using dimensions obtained from architectural plans and details.

INTRODUCTORY
INFORMATION:

Hip and valley rafters are seldom shown true size and shape in the architect's plans and details. Roof framing dimensions seldom provide true lengths as these rafters are installed 45° to normal building lines and architects draw plans and elevations to normal building lines.

The carpenter must therefore take what information the architect has given him along with his knowledge of rafters and roof framing, and calculate, lay out, and cut rafters appropriately to meet the architects requirements.

REFERENCES:

Information Sheet V-D-1 (IS), Hip and Valley Rafters
Booklet, Swansons Book of Rafter Lengths
Carpenters framing square, Rafter Tables

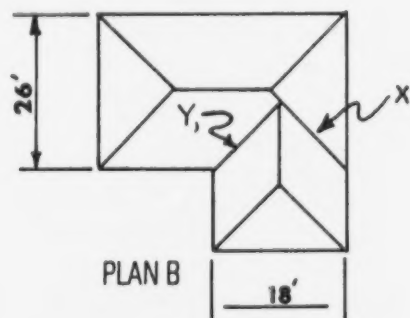
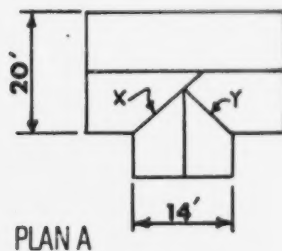
QUESTIONS OR PROBLEMS:

Using any means available to the modern carpenter, solve the following hip/valley rafter problems:

1. Determine following hip/valley rafter lengths!
 - a. Unit length, 1/3 pitch on common rafter 18.76"
 - b. Unit length, 9 in 12 slope on common rafter 19.21"
 - c. Unit length, 5 in 12 slope on common rafter 17.69"
 - d. Unit length, 1/2 pitch on common rafter 20.78"
 - e. Unit length, 4'-3" rise, 8'-6" run on common rafter 18.00"
 - f. Total length, 5'-6" rise, 7'-4" run on common rafter 8'-8 13/16"
 - g. Total length, 4'-4" rise, 8'-8" run on common rafter 13'-0"

V-D-1(AS)
KEY

2. Building span is 28'-0" with a 1/3 equal pitch roof containing hips. What is the theoretic length of the hip rafters? 21'-10 5/8"
3. A 24'-0" wide building has an equal pitch hip roof that slopes 7 in 12. What is the theoretic hip rafter length? 18'-4 3/8"
4. The common rafters of a hip roof have a 13'-8" run and a 6'-10" rise. What is the length of the hip rafters? 20'-5 7/8"
5. A 25' x 50' building has a 5 in 12 hip roof with a 1'-9" overhang. What is the total length of each hip rafter? 21'-0 1/16"
6. The common rafters of a hip roof measures 10'-0" run and 5'-0" rise with a 1'-6" overhang. What standard length 2 x 8 is required to make the hip rafters? 18'-0"
7. A 24' x 36' building has a hip roof of 1/4 pitch with a 2'-0" overhang. What length are the hip rafters? 21'-0"
8. A T-shaped gable roof, each gable spanning 16'-0", intersects to form a valley. The roofs have 1/3 pitch and 16" overhang. What is the length of the valley rafters? 14'-7"
9. A 20' wide gable roof has a 14' wide gable roof tee into it. Both roofs have 7 in 12 slopes. (see plan A). What is the major valley rafter length (X)? What is the minor valley rafter length (Y)?
(X) 15'-3 5/8"
(Y) 10'-8 1/2"



10. A 26' wide hip roof forms an elbow with an 18' wide hip roof. Both roofs have a 1/3 pitch and a 2'-0" overhang (see plan B). What is the length of hip rafter for the 26' roof (X)? What is the length of the valley rafter for the 18' roof (Y)?
(X) 21'-10 5/8"
(Y) 15'-7 5/8"

INSTRUCTOR'S PLAN
MANIPULATIVE LESSON

V-D-1(S)

TASK: Lay Out And Cut Hip And Valley Rafters

AIM: The student(s) will be able to lay out and cut the hip and valley rafters using the framing square and step-off method of lay out to the dimensions provided on architectural prints.

TOOLS AND EQUIPMENT: 25' steel measuring tape, framing square, marking pen or pencil, saw horses, portable circular power saw (6½" min.), extension cord

MATERIALS: 2" framing lumber, size and type as per plans and specifications.

TEACHING AIDS: V-D-1 Job and Task sheets

REFERENCES: Blueprints and Specifications

PREREQUISITE EXPERIENCE OF THE LEARNER: The student(s) must have successfully have completed previous lessons V-A-1(1), V-A-2(1), V-B-1(1), and V-D-1(1). The student(s) must continue to display a sincere interest in learning the building trades.

CHECKING STANDARDS:

1. Rafter length calculations
2. Rafter material selection
3. Accuracy of rafter layout
4. Rafter fit

I. PREPARATION: (OF THE LEARNER - MOTIVATION)

Hip and valley rafters are roof frame members that form intersection lines in the framework of adjacent intersecting roof slopes. Hip rafters extend from outside corners diagonally to the ridge and form a raised area. Valley rafters are similar, but extend from an inside corner and form a depressed area.

On equal pitch slopes, the diagonal formed by their intersection bisects the angle set between the slopes. Normally this diagonal is 45°, therefore hip and/or valley rafters normally run 45° to common rafters.

When laying out hip/valley rafter lengths, use the same rise as common rafters and the same number of units of run as common rafters, but on a 45° diagonal, each unit is longer. When calculated, the unit run equals 16.97" or 17".

 II. PRESENTATION: (OF THE SKILLS)

STEPS	KEY POINTS (THINGS TO REMEMBER TO SAY OR DO)
1. Study Plans/Specifications	1. Obtain key dimensions a. Rise; run; span b. Slope and/or pitch 2. Determine material type, grade, size 3. Become familiar with rafter requirements
2. Calculate Rafter Length	1. Read "length of hip or valley rafter per foot of run" a. On body of framing square b. Under "inch" equal to "rise in inches" 2. Multiply "length per foot of run" X the "number of units of run" of common rafter <u>Note:</u> Include rafter overhang in total units run when calculating overall rafter length
3. Select Rafter Material	1. To be next standard length over calculated length 2. Type, grade, size as per plans, specifications 3. Relatively straight, free of warp, major flaws
4. Position Rafter Material	1. On saw horses or other work surface 2. Flat on one face 3. Convenient for layout; cutting
5. Set Rise And Run	1. On framing square 2. With wood straightedge 3. Clamp edge nearest elbow diagonally across face to: a. 17" Mark outside of body b. "Rise in inches" outside of tongue
6. Position Framing Square	1. On rafter material 2. At top end of rafter 3. With elbow across face of rafter 4. With straightedge on top edge of rafter 5. With tongue in plumb position 6. With body in level position

7. Lay Out Rafter Length

1. Mark ridge plumb line (theoretic center of ridge)
 - a. Along outside edge of tongue
 - b. On face of rafter
2. Calculate odd unit run (if any)
 - a. Set up ratio:

$$\frac{\text{unit rise in inches}}{12} \times \frac{x}{17}$$
 - b. Cross multiply!
 Example: $\frac{6}{12} \div \frac{x}{17} = \frac{102}{12} = 8.5''$ odd unit
3. Step-off odd unit run
 - a. Measure "inches" calculated along outside of body
 - b. Mark point measured
 - c. Slide straightedge along rafter top edge
 - d. Align outside of tongue with point marked
 - e. Mark plumb line outside of tongue
4. Step-off full units run (17")
 - a. Measure 17" units along outside of body
 - b. Slide straightedge along rafter top edge
 - c. Align outside of tongue with points measured
 - d. Mark plumb lines outside of tongue

Note: Measure and mark units accurately!
 Plum line of last unit denotes building plumb line
5. Step-off rafter tail
 - a. Use framing square and straight-edge
 - b. Similar as in keypoints 3 & 4 (above)

8. Lay Out Ridge Allowance

1. Position straightedge and framing square
 - a. On top edge of rafter
 - b. With elbow of square across face of rafter
 - c. With outside of tongue to ridge center plumb line
2. Measure and mark one-half of 45° thickness of ridgeboard (1 1/16" on 2" stock)
 - a. From corner of elbow
 - b. Along outside of body (level line)
3. Adjust framing square to align outside of tongue with mark

9. Lay Out Side Cuts

4. Mark rafter plumb cut line outside of tongue

Note: With framing square still in position

1. Measure and mark one-half of the rafter thickness
 - a. From elbow of framing square
 - b. Along outside of body
2. Draw side cut line
 - a. Slide framing square and straightedge
 - b. To align outside of tongue with point measured
 - c. Mark line flush with outside of tongue
3. Draw bevel cut lines
 - a. Turn rafter on edge, top edge up
 - b. Square lines across top at plumb cut line; at side cut line
 - c. Draw centerline of material thickness
 - d. Connect points center-at-plumb cut with edges at side cuts

Note: The rafter tail is laid out similarly but in the opposite direction

10. Make Side Cuts With Portable Circular Saw

1. Mark edge centerline on scrap 2" x 6"
2. Set hand screw clamp square on 2" x 6"
3. Make double side cut 45° using clamp as guide for saw base of portable power saw

Note: Turn 2" x 6" over for second cut to keep guide on operators left

4. Verify:
 - a. Sawcuts intersect at center of material thickness
 - b. Dimension from intersection of sawcuts to edge of clamp (guide for saw)
5. Draw guideline on hip/valley rafter
 - a. On face of rafter
 - b. Parallel to plumb cut line
 - c. "x" dimension "verified" from plumb cut line to clamp (saw guide)
 - d. Position clamp on rafter at line
 - e. Make double cuts on rafter same as 2" x 6" scrap

11. Lay Out, Cut Bird's-mouth

1. Measure vertical thickness of common rafter
 - a. At building plumb line
 - b. From the top of the rafter to the corner of bird's-mouth
2. Transfer dimension measured
 - a. To same position
 - b. On hip/valley rafter
 - c. Mark point measured
3. Determine amount of additional drop (hip rafters only)

Note: This additional drop is an allowance to offset the top edges of hip rafters which will actually protrude above the plane of the roof if not backed or dropped slightly

- a. Set outside of framing square to the cut of the rafter (rise and run) along top edge
- b. Measure one-half the rafter thickness from the top edge along the body (run)
- c. Scribe line parallel to top edge through the point measured

Note: This line is the depth for backing, or additional depth of bird's-mouth for dropping

4. Subtract amount layed out (key point #3) from dimension measured (key point #2) and mark new point
5. Draw level line through point marked by:
 - a. Sliding straightedge and framing square along top edge of rafter
 - b. Align body of square with mark on building plumb line
6. Adjust portable circular power saw
 - a. Follow safety rules - unplug saw
 - b. Use combination blade
 - c. Adjust square with base
 - d. Set depth of cut equal to material thickness plus tooth depth
7. Cut bird's-mouth
 - a. Straight; square
 - b. Saw base on rafter - level cut
 - c. Saw kerf in waste side of line

12. Lay Out Heel Side Cuts
Valley Rafters

1. Turn valley rafter bottom edge up
2. Square line
 - a. Across bottom edge
 - b. Aligned with building plumb line
3. Scribe centerline of material thickness
 - a. From line squared
 - b. Along rafter tail
4. Read "side cut of hip and valley rafter"
 - a. On rafter table of framing square
 - b. Under inch number equal to "inches rise per foot run" of rafter
5. Position framing square
 - a. Flat on rafter edge
 - b. With tongue towards bird's-mouth
 - c. With 12" dimension, outside tongue, at intersection of squared line and centerline
 - d. With "dimension read", outside of body, on material centerline opposite end
6. Mark side cut
 - a. On bottom edge of rafter
 - b. Outside of framing square tongue

Note: Turn framing square over, repeat keypoints #5 & #6 opposite side cut

13. Lay Out Rafter Tail

1. Similar to rafter length
 - a. Use step-off method of lay out
 - b. Convert rafter overhang into units of run
2. Draw rafter tail plumb cut line
 - a. Parallel to building plumb line
 - b. With tongue of framing square set by straightedge at top of rafter
3. Scribe line parallel with rafter top
 - a. To pass thru vertex of bird's-mouth
 - b. To intersect rafter tail plumb line
4. Draw rafter tail bottom (level) cut
 - a. To pass thru intersection of parallel line and rafter tail plumb line
 - b. Use straightedge and framing square to align tongue (level) at intersection point

II. PRESENTATION (CONT'.)

V-D-1(S)

4. Draw rafter tail double side cuts similar to ridge or bird's-mouth heel side cuts, whichever is most convenient, but in the opposite direction

III. APPLICATION (PRACTICE BY LEARNER UNDER CLOSE SUPERVISION)

Instructor demonstrate lay out procedures with lesson presentation; demonstrate cutting procedures, tool safety

Instructor pass out V-D-1 Job and Task sheets

Students practice job and tasks as per plans and details under close supervision of instructor

IV. VERIFICATION AND/OR EVALUATION (CHECK ON STUDENT'S ABILITY)

Performance Test!

Students to lay out and cut hip and valley rafters as per blueprints and specifications

V. SUMMARY (TELL THE STEPS ON PROCEDURE AS TO WHAT, HOW, AND WHY. REVIEW CHECKING STANDARDS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENTS.)

Hip and valley rafters are roof frame members that form intersection lines in the framework of adjacent intersecting roof slopes. Hip rafters extend from outside building corners diagonally to the ridge and form a raised area. Valley rafters are similar, but extend from inside corners and form a depressed area.

On equal pitch roof slopes set 90° apart, the intersection occurs at a 45° angle therefore hip and valley rafters run 45° to common rafters. Hip and valley rafters have the same rise and the same number of units of run as a common rafter but the length of its unit of run is greater than that of a common rafter because it is at a 45° diagonal to the common rafter. When calculated mathematically is the square root of 12 squared + 12 squared, $\sqrt{12^2 + 12^2}$, which equals 16.97" or 17" for layout.

To Lay Out A Hip Or Valley Rafter:

1. Clamp a straightedge diagonally across a framing square so the edge near the elbow will be on the "rise" inches outside the tongue and on the 17" mark outside the blade.

2. Position the straightedge and the framing square on the top edge of the rafter at the top end, with the elbow across the face of the rafter - draw rafter ridge center plumb line outside of tongue.
3. Step-off rafter lengths in units of 17" similar to stepping-off common rafters in units of 12" - draw building plumb line outside of tongue - continue to step-off rafter tail in similar manner - draw tail plumb cut line.
4. Lay out bird's-mouth by measuring vertical thickness "top of rafter to vertex of bird's-mouth" at building plumb line on common rafter. Transfer and mark same on hip or valley rafter. Slide straightedge and framing square to align outside of body with mark - draw level cut of bird's-mouth outside of body.
5. Drop hip rafters to bring top edges into plane of rafter slopes. Position-framing square elbow flat across face of rafter with rise and run set along outside of the square at top edge of rafter. Measure one-half of rafter thickness from top edge along body (run). Scribe line parallel to top through point measured.

Note: This line is additional depth of bird's-mouth for dropping - draw new seat or level cut line in bird's-mouth per step #4 above.

6. To lay out the level cut of rafter tail scribe a line through the vertex of the bird's-mouth, parallel to the rafter top to intersect the tail plumb cut line. Draw a level line thru this intersection using the straightedge and framing square to align.
7. To lay out the ridge plumb cut position straightedge and framing square on the top edge at the top end of rafter as in step #2 (summary) with outside of tongue to the ridge center plumb line. Measure and mark one-half of 45° thickness of the ridge board (1 1/16" on 2" stock) from the elbow along the outside of the body (level line). Slide straightedge and framing square to align outside of tongue with mark - draw rafter plumb cut line.
8. To lay out side cuts, position straightedge with framing square to plumb cut line. Measure and mark one-half of rafter thickness from elbow along outside of the tongue. Slide straightedge to align outside of tongue with mark - draw side cut line parallel to plumb cut line. Turn rafter top edge up, square line across top aligned with side cut line, plumb cut line. Draw edge centerline! Connect bevels center-at-plumb cut with edges-at-side cut.

Note: The bird's-mouth plumb cut for valley rafters is laid out similarly except on the bottom of the rafter and the tails cuts are similar except in the opposite direction.

SUGGESTED READING FOR THE STUDENT:

Modern Carpentry, Unit 9
Guide to Residential Construction, Unit 19

THE NEXT LESSON IS:

V-D-2(S) "Lay Out And Cut Jack Rafters"

JOB SHEET
ON
ROOF FRAMING

V-D-1(J)

NAME OF JOB: Lay Out And Cut Hip And Valley Rafters

DRAWINGS: Architects floor plan, roof framing plan, sections and details

MATERIALS: 2" framing lumber as per plans and specifications

TOOLS AND EQUIPMENT: 25' Steel measuring tape, straightedge clamp, framing square, marking pen or pencil, portable circular power saw, cross-cut saw, hand-screw clamp

GENERAL INSTRUCTIONS: Study the architects plans and details. Become familiar with the roof framing requirements and dimensions. Plan your work! Make all measurements and marks accurately. Double check lay outs. Practice tool and operator safety in the use of power tools and equipment.

PROCEDURES AND/OR TASKS: V-D-1(TS), Select Rafter Material - Hip And Valley Rafters
V-D-1a(TS), Lay Out Hip And Valley Rafter Lengths
V-D-1b(TS), Lay Out Hip And Valley Rafter Ridge Allowance And Side Cuts
V-D-1c(TS), Lay Out Hip And Valley Rafter's Bird's-mouth
V-D-1d(TS), Lay Out Hip And Valley Rafter Tails
V-D-1e(TS), Cut Hip And Valley Rafters

CHECK POINTS: 1. Rafter calculations; lengths
2. Accuracy of layout
3. Adjustment, operating condition of saw
4. Fit of cut rafters

TASK SHEET

V-D-1(TS)

TASK: Select Rafter Material - Hip/Valley Rafters
 JOB: Roof Framing
 TRADE: Building Trades
 TOOLS AND MATERIALS: 25' steel measuring tape, framing square 2" framing lumber as per plans and specifications

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Study Plans and Specifications	1. Obtain critical dimensions: - Rise, run - Slope or pitch - Overhang (if any) - Building width, length 2. Determine material type, grade, size
2. Calculate Rafter Length	1. Read "length of hip or valley rafter per foot of run" - On body of framing square - Under "inch number" equal to rise in inches 2. Multiply "length" per foot run "x" number of units (12") run of common rafter <u>Note:</u> Product is rafter theoretic length 3. Multiply "length" per foot run "x" number of units (12") run of overhang, common rafter <u>Note:</u> Product is rafter tail length 4. Total the products
3. Select Rafter Material	1. Size, type, and grade as per specifications 2. Next standard length over calculated length - Relatively straight, free of warp - Free of major flaws

TASK SHEET

V-D-1a(TS)

TASK: Lay Out Hip/Valley Rafter Lengths

JOB: Roof Framing

TRADE: Building Trades

TOOLS AND MATERIALS: Straightedge clamp V-B-1(TS), framing square, marking pen or pencil, 2" framing lumber as per plans and specifications

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Position Material	1. Flat on one face 2. On saw horses, other work surface 3. Convenient for lay out
2. Set Rise And Run	1. On framing square 2. With wood straightedge 3. Edge nearest elbow to: a. 17" mark outside of body b. "Rise in inches" outside of tongue 4. Clamp diagonally across face
3. Position Framing Square	1. At top end of rafter 2. With straightedge to top edge of rafter 3. With elbow across face of rafter 4. So that tongue is plumb with respect to rafter position
4. Mark Ridge Center Plumb Line (Theoretical)	1. On face of rafter 2. Outside of tongue 3. At top end of rafter
5. Step-off Rafter Length (Theoretic)	1. Measure odd unit a. Along outside of body b. From corner of elbow 2. Mark odd unit run a. Slide framing square and straightedge along top of rafter b. Align outside of tongue with point measured c. Mark plumb line outside of tongue

TASK BREAKDOWN: (Cont'.)

V-D-1a(TS)

3. Measure full units run (17") each
 - a. Along outside of body one-at-a-time
 - b. From corner of elbow
4. Mark full units run
 - a. Slide framing square and straightedge along top of rafter
 - b. To align outside of tongue with point measured each unit (17")
 - c. Mark plumb line outside of tongue each unit

Note: The plumb line of the last unit denotes the building plumb line

6. Step-off Rafter Tail

1. Similar to rafter length, step #5
2. Use straightedge and framing square
3. Measure and mark units of run in overhang

Note: Last plumb line marked indicates rafter tail

Check Point:

Check rafter length!

1. Calculate rafter length (step #2 this task)
2. Measure stepped-off length
 - a. Along top edge of rafter
 - b. From ridge center plumb line to building plumb line

Note: Dimension should agree with calculation.

TASK SHEET

V-D-1b(TS)

TASK: Lay Out Hip/Valley Rafter Ridge Allowance And Side Cuts
 JOB: Roof Framing
 TRADE: Building Trades
 TOOLS AND MATERIALS: Framing square, marking pen or pencil, 2" framing lumber as per plans and specifications

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Lay Out Ridge Allowance	<u>Note:</u> With rafter material in horizontal position for lay out
A. Position Straightedge And Framing Square	1. On top edge of rafter 2. At top end of rafter 3. With elbow of square across face of rafter 4. With outside of tongue to ridge center plumb line
B. Measure Ridge Allowance	<u>Note:</u> Ridge allowance is one-half of the 45° thickness of ridge board measured along the horizontal. On 2" material this is equal to 1 1/16" 1. From elbow of framing square 2. Along outside of body (level line) 3. Mark point measured on face of rafter
C. Adjust Framing Square	1. Slide straightedge along rafter top 2. To align outside of framing square tongue 3. With point measured (step #2)
D. Mark Ridge Plumb Line	1. Outside of tongue 2. While holding square in position
2. Lay Out Side Cuts	<u>Note:</u> With square still positioned
A. Measure	1. One-half of rafter thickness (3/4") 2. From the elbow of the framing square 3. Along the outside of the body (level line)

TASK BREAKDOWN (Cont'.)

V-D-1b(TS)

B. Adjust Framing Square

4. Mark point measured on face of rafter

1. Slide straightedge along rafter top

2. To align outside of framing square tongue

3. With point measured (step #5)

C. Mark Side Cut Plumb Line

1. Outside of tongue

2. While holding square in position

D. Mark Bevel Cut Line(s)

1. Turn rafter on edge with top edge up

2. Square lines across the top edge

a. At plumb cut line

b. At side cut line

3. Draw centerline of material thickness

4. Connect points - center at plumb cut with edges at side cuts

TASK SHEET

V-D-1c(TS)

TASK: Lay Out Hip And Valley Rafters Bird's-mouth
 JOB: Roof Framing
 TRADE: Building Trades
 TOOLS AND MATERIALS: Framing square, marking pen or pencil, 2" framing lumber as per plans and specifications

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Measure Vertical Thickness	1. Of common rafter 2. At building plumb line (marked) 3. From top of rafter to vertex of bird's-mouth
2. Determine Drop/Backing (Hip Rafter Only)	1. Set outside of framing square a. To the cut of the roof (rise and run) b. Along the top edge of the rafter <u>Note:</u> Cut of the roof is already set with straightedge clamped to square 2. Measure one-half of rafter thickness (3/4") a. Along framing square body b. From top edge of rafter (17" mark) 3. Scribe line a. Parallel to top edge of rafter b. Through point measured <u>Note:</u> This line is the depth for backing, or additional depth of bird's-mouth for dropping 4. Subtract "drop" (laid out) from "vertical thickness" measured (step #1)
3. Subtract Dimension	1. From vertical dimension measured (step #1) 2. On hip/valley rafter 3. Mark point measured
4. Draw Level Line	1. Through point marked 2. Slide straightedge and framing square along top edge of rafter

TASK BEAKDOWN (Cont'.)

V-D-1c(TS)

3. Align outside body of square with mark on building plumb line
5. Turn Valley Rafters Only
 1. Bottom edge up
 2. Convenient for lay out
6. Square Line
 1. Across bottom edge
 2. Aligned with building plumb line
7. Scribe Centerline
 1. Of rafter material thickness
 2. Through squared line
 3. Along rafter tail
8. Read Side Cut
 1. Of hip and valley rafter
 2. On rafter table of framing square
 3. Under inch number equal to "inches rise per foot run" of rafter
9. Position Framing Square
 1. Flat on rafter edge
 2. With tongue towards bird's-mouth
 3. With 12" dimension, outside of tongue; at intersection of squared line and material centerline
 4. With "dimension read" outside of body on material centerline, opposite end
10. Mark Side Cut
 1. On bottom edge of rafter
 2. Outside of framing square tongue

Note: Turn framing square over, repeat steps 9 & 10, opposite side cut

TASK SHEET

V-D-1d(TS)

TASK: Lay Out Hip/Valley Rafter Tails

JOB: Roof Framing

TRADE: Building Trades

TOOLS AND MATERIALS: Framing square, marking pen or pencil, straightedge clamp, 2" framing lumber as per plans and specifications

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Step-off Rafter Tail Length	1. Similar as rafter length 2. Position straightedge and framing square a. On rafter top edge b. With outside of tongue flush to building plumb line (marked) 2. Measure full units of run (17") a. One-at-a-time b. Along outside of body c. From corner of elbow 3. Mark full units run a. Slide straightedge along rafter top b. To align outside of tongue with point measured c. Mark plumb line outside of tongue 4. Measure odd unit run (if any) a. Along outside of body b. From corner of elbow 5. Mark rafter tail plumb line a. Slide straightedge along rafter top b. Align outside of tongue with point measured c. Draw plumb line outside of tongue <u>Note:</u> This step may be performed in task V-D-1a(TS)
2. Lay Out Level Cut (Bottom of Rafter)	1. Scribe line on face of rafter a. Parallel to rafter top b. Through vertex of bird's-mouth c. To rafter tail plumb line

2. Position straightedge and framing square
 - a. On rafter top edge
 - b. Slide straightedge along rafter top
 - c. Align outside of framing square body with intersection of scribed line and rafter tail plumb line
 3. Mark level cut outside of body
-
3. Lay Out Rafter Tail Side Cuts (Hip Rafters Only)
 1. Turn rafter top edge up
 2. Square line across rafter top edge aligned with rafter tail plumb line
 3. Scribe rafter material centerline along rafter tail top edge
 4. Read "side cut of hip and valley rafter"
 - a. On rafter table of framing square
 - b. Under inch number equal to "inches rise per foot run" of rafter
 5. Position framing square
 - a. Flat on rafter top edge
 - b. With tongue towards rafter tail
 - c. With 12" dimension outside of tongue on intersection of squared line and material centerline
 - d. With "dimension read" outside of body on material centerline, opposite end
 6. Mark "side cut" outside of tongue
 7. Turn framing square over, repeat key points 5 & 6, opposite side

TASK SHEET

V-D-1e(TS)

TASK: Cut Hip/Valley Rafter

JOB: Roof Framing

TRADE: Building Trades

TOOLS AND MATERIALS: Portable circular power saw (6 1/2" min. with combination blade), cross-cut saw (hand), hand screw clamp, framing square, marking pen/pencil, 2" framing lumber as per plans

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Check Power Saw Dimensions	1. On scrap 2" x 6" a. Mark edge centerline b. Mark line square across face c. Approx. 8" from one end 2. Set hand screw clamp a. Square to line b. With 8" end exposed 3. Adjust power saw a. To make 45° cut b. Follow all safety rules - unplug saw 4. Make double side cuts 45° a. Use clamp as guide for saw base b. Keep guide on operators left turn 2" x 6" over for second cut c. Practice all safety in use of saw 5. Verify: a. Saw cuts intersect at center of material thickness b. Dimension from intersection of saw cuts to edge of clamp (guide line)
2. Make Side Cuts	1. Measure dimension verified a. From rafter plumb cut line b. Square to plumb cut line c. Use framing square and straightedge similar to rafter lay out 2. Mark guide line a. Through point measured b. Parallel to plumb line

TASK BREAKDOWN (Cont.)

V-D-1e(TS)

3. Cut Bird's-mouth

3. Set hand screw clamp
 - a. Square to line
 - b. Opposite side from plumb line
4. Make double side cuts 45° same as step #1, key point #4 -above
1. Adjust portable power saw
 - a. Follow safety rules - unplug saw
 - b. Blade square with base
 - c. Depth of cut equal material thickness plus tooth depth
2. Cut bird's-mouth
 - a. Exercise saw safety
 - b. Keep saw base on rafter material

INSTRUCTOR'S PLAN
INFORMATIONAL LESSON

V-D-2(I)

SUBJECT: Jack Rafters

AIM: The student will be able to identify the different jack rafters by their position in the roof frame; calculate their lengths and explain the layout procedure for cutting and fitting jack rafters.

TEACHING AIDS: Information Sheet V-D-2(IS)
Assignment Sheet V-D-2(AS)

MATERIALS: None

REFERENCES: Wagner, Willis H., Modern Carpentry, Unit 9
Jones, Raymond P. and Ball, John E., Framing Sheathing and Insulation, Unit 16
Feirer, John L., Guide to Modern Carpentry, Unit 20

PREREQUISITE EXPERIENCE OF THE LEARNER: The student must have successfully completed previous information lessons in major block V, Roof Framing and continue to display inthusiasm for learning the building trades.

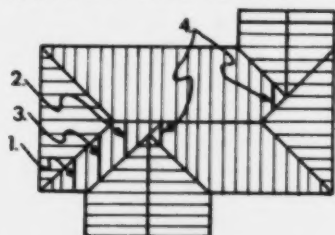
I. PREPARATION (OF THE LEARNER - MOTIVATION)

Jack rafters are used in conjunction with hip and valley rafters. Jack rafters, like common rafters, run square to mormal building lines. They have the same slope or pitch as common rafters and even maintain the same equal spacing between them. In fact, you might say that jack rafters are common rafters foreshortened only by the intersection of hip and/or valley rafters.

There are three types of jack rafters. Hip jacks - run from the building wall plates to the hip rafter; Valley jacks - run from the roof ridge board to the valley rafter; and Cripple jacks - run from a hip rafter to a valley rafter. The framing carpenter must be able to layout and cut jack rafters to fit that will maintain proper spacing while providing the proper surface plane and slope for attaching roofing materials.

II. PRESENTATION (OF THE INFORMATION)

INSTRUCTIONAL TOPICS TEACHING POINTS	THINGS FOR STUDENTS TO DO THINGS FOR INSTRUCTOR TO DO OR SAY
A. Types of Jack Rafters	NOTE: Illustrate on chalkboard 1. Hip jack-extends from a hip rafter to the rafter plate 2. Valley jack-extends from a valley rafter to the ridge board 3. Cripple jacks-(2) kinds; do not contact either a plate or a ridge a. Valley cripple jacks 1) extend between long and short valley rafters

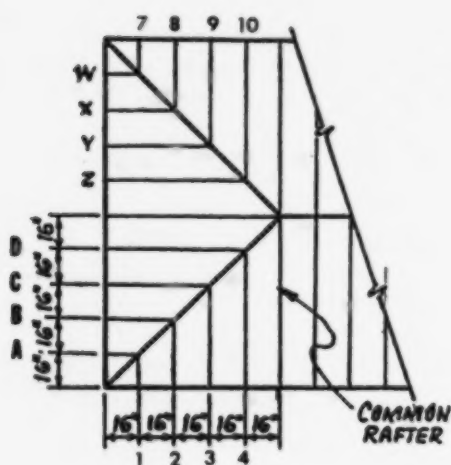


ROOF FRAMING PLAN SHOWING:

1. HIP JACK RAFTER
2. VALLEY JACK RAFTER
3. HIP-VALLEY CRIPPLE JACK
4. VALLEY-TO-VALLEY CRIPPLE JACK

B. Size and Spacing of Jack Rafter

C. Jack Rafter Lengths (Theoretic)



2) on roof additions with smaller building spans

b. Hip-valley cripple jacks-extend from hip rafter to valley rafter

1. Size, thickness x width, same as common rafters in a roof frame
2. Spacing is same as common rafters
3. Lengths are calculated similar to common rafters

1. Are laid out similar to common rafters
 - a. Have same rise and run as common rafters
 - b. Hip jacks have same rafter tail as common rafters
 - c. Valley jacks have same ridge clearance as common rafters
 - d. All jacks have shortening allowance and side cuts to fit against hip or valleys; cripple jacks at both ends
2. Unit length is the hypotenuse of a right triangle with:
 - a. The unit run as base
 - b. The unit rise as height
3. Unit length can be calculated (Pythagorean's Theorem) or looked up in a rafter tables
 - a. Under "inches rise"
 - b. For common rafters

Example: On a 7 in 12 slope, the unit length of a jack rafter is the square root of $(7^2 + 12^2)$, or 13.89"

4. The total length of jack rafters is based on their unit length x no. of units of run
5. The number of units of run depends on their location and spacing
 - a. Shortest hip jack on 16" spacing has 16" run

NOTE: Illustrate on chalkboard

- b. A 16" run is 1.33 units of run $(16 \div 12)$
- c. $13.89 \text{ unit length} \times 1.33 \text{ units} = 18.47"$ or $18 \frac{1}{2}"$, total length of the shortest jack rafter
6. Dimension calculated in key point #5 is also the "common difference" in the length of jacks
 - a. Rafter #2 would be $2 \times 18 \frac{1}{2}"$ lg., or 37"
 - b. Rafter #3 would be $3 \times 18 \frac{1}{2}"$ lg., or $55 \frac{1}{2}"$

- c. Rafter #4 would be $4 \times 18 \frac{1}{2}"$ lg., or 74"
- 7. Common difference can also be found in rafter tables on framing square
 - a. Read "inches rise" of required jack rafter
 - b. Read "Difference in length of jacks 16" centers" on third line; under rise = $18 \frac{1}{2}"$
 - c. Read "Difference in length of jacks 24" centers" on 4th line if rafter spacing is 24"
- 8. Common difference(s) subtracted from common rafters for jack rafter lengths

NOTE: Use same example and illustration

- a. Common rafter with 7 in 12 slope has total run of 6'-8"; 6.66 units of run
- b. Common rafter length (theoretic) = $92.507"$ or $92 \frac{1}{2}"$ ($6.66 \text{ units} \times 13.89 \text{ unit length}$)
- c. Rafter #4 would be $92 \frac{1}{2}" - 18 \frac{1}{2}" = 74"$
- d. rafter #3 would be $92 \frac{1}{2}" - (2 \times 18 \frac{1}{2})$ or $37 = 55 \frac{1}{2}"$
- 9. Corresponding lengths (theoretic) of jack

- a. Occur between all types of jack rafters
- b. Depend on location and type
- c. Best determined with framing diagram and observation (see illustration)

Example: Rafters 1, A, W, 7 have corresponding lengths

Rafters 3, C, Y, 9 have corresponding lengths

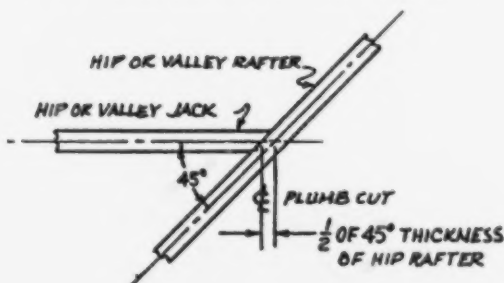
10. Like jack rafters

- a. Occur in like situations and spacing
- b. Occur in different area of roof frame

Example: Rafters 1 and W are alike

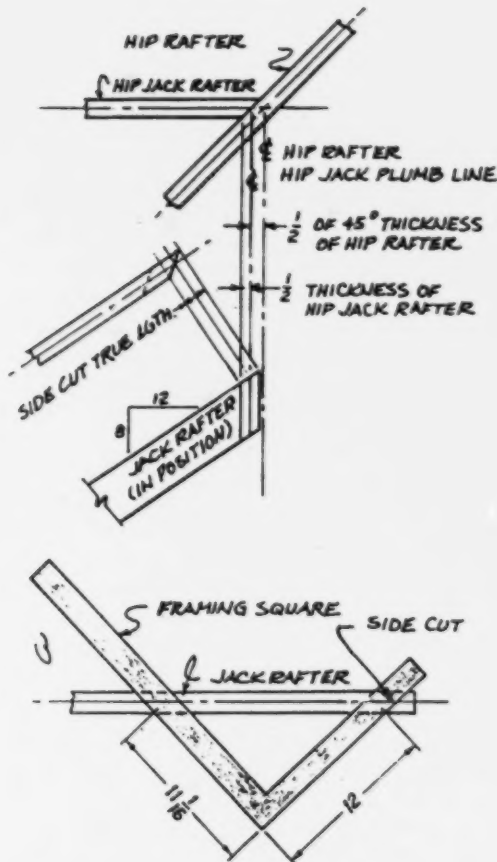
Rafters 9 and C are alike

D. Shortening Allowance(s)



- 1. May occur on one or both ends of a jack rafter
- 2. At ridge board
 - a. Is one-half the thickness of the ridge board
 - b. Measured horizontally
 - c. The same as common rafters
- 3. At hip or valley rafter
 - a. Is one-half the 45° thickness of a hip or valley rafter

E. Sides Cuts



b. Measured horizontally

NOTE: On 2" material (1 1/2") this equals 1 1/16"

1. Are required on all jack rafters to fit flush against hip or valley rafters
2. May be laid out similar to the first side cut of a hip or valley rafter

a. Draw edge centerline on top of jack rafter

b. Measure back "one-half thickness of jack rafter" from jack rafter plumb line and mark "bevel line" parallel to "plumb line"

NOTE: Bevel line should be marked on side to which bevel is made

c. Square a line across the top edge at the plumb line

d. Connect edge at bevel line with center at plumb line and draw plumb cut line across the top

3. May be laid out with framing square
- a. Refer to rafter table "Side Cuts of Jacks"

b. Read figure under "inches" rise

Example: 7" rise = 11 1/16"

c. Place framing square flat on top edge of jack rafter with:

- 1) tongue across area of desired side cut
- 2) set 12" mark, outside of tongue on edge of rafter
- 3) set 11 1/16" mark, outside of body, on same edge of rafter

d. Draw side cut line at tongue while holding square flush against edge of rafter

F. Bird's-Mouth and Overhang

1. Occur only on hip jack rafters
2. Are identical to common rafters
3. Are laid out and cut the same as common rafters

III. APPLICATION (DRILL, ILLUSTRATIONS, ANALOGIES, ORAL QUESTIONS, OR ASSIGNMENTS, MAKING INVESTIGATIONS OR EXPERIMENTS, NOTE TAKING, MAKING SKETCHES, PARTICIPATING IN DISCUSSION.)

Instructor: Passout Assignment Sheet V-D-2(AS)
Discuss assignment instruction with students

Students: Complete assignment as per instructions
Submit to instructor for grade

 IV. VERIFICATION AND/OR EVALUATION (FINAL CHECK ON STUDENT'S COMPREHENSION OF MATERIALS PRESENTED.)

True-False

- T 1. A jack rafter is a shortened common rafter that may be framed to a hip rafter, a valley rafter, or both.
- T 2. A hip jack rafter extends from a hip rafter to a top plate.
- F 3. A valley rafter extends from a valley rafter to a top plate.
- T 4. The unit of rise of a jack rafter is always the same as the unit of rise of a common rafter.
- T 5. Jack rafters are always on the same spacing as common rafters.
- F 6. Cripple jacks always extend from a hip rafter to a valley rafter.
- T 7. The theoretic length of a jack rafter is the hypotenuse of a right triangle whose base is its run and height is its rise.
- T 8. The length of the shortest jack rafter on equal spacing is also the common difference in lengths of jack rafters.
- T 9. Common difference of lengths of jack rafters can be found on the framing square.
- F 10. The shortening allowance for jack rafters is one-half the thickness of the jack rafter.
- T 11. Ridge plumb cuts of valley jacks are the same as common rafters.
- T 12. Side cuts on jack rafters can be laid out and made similar to the first cut of a double side cut on a hip or valley rafter.
- F 13. The bird's-mouth on valley jacks is the same as on common rafters.
- T 14. A framing plan/diagram is beneficial in determining duplicate jack rafter lengths.
- T 15. If the shortest of (5) equally spaced hip jacks is 19 1/4", the longest is 96 1/4" long.

 V. SUMMARY (GIVE A BRIEF ACCOUNT OF EACH TOPIC REEMPHASIZING THE IMPORTANT POINTS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENT.)

Jack rafters are common rafters that have been shortened to frame into hip and/or valley rafters in that style of roof. There are four kinds of jacks rafters: hip jack, extend from a hip rafter to a rafter plate; valley jacks, extend from a valley rafter to a ridge board; valley cripple jacks, extend between two valley rafters; and hip-valley cripple jacks, extend from hip to valley rafters.

Jack rafters are the same as common rafters in every respect except where they are cut off. Valley jacks have the same shortening allowance and plumb cut at the ridge -- hip jacks have the same bird's-mouth and overhang at the tail -- all have the same spacing, slope, unit run, and unit rise. The length of a

jack rafter is based on the unit length (same as common rafter) x number of units of run. Since hip/valley rafters are set a 45° angles to common rafters, the longest hip jack rafter would be diminished by deducting the amount of the spacing from the run.

Example: Common rafters spaced 16" O.C. slope 7 in 12 on 10'-0 run
Lgth. Common Rafter per Foot Run 13.89" x 10 units = 138.900
Lgth. Common Rafter per Foot Run 13.89" x 8.66 units = 120.375
difference = 18.525

The difference in these lengths would be the common difference for all jack rafters on this slope and spacing.

All lengths are theoretic, that is, calculated to the center of the ridge board, hip or valley rafter. In actual practice, a shortening allowance must be included to allow for the material thickness of the ridge board, and hip or valley rafter. This allowance at the ridge amounts to one-half the thickness of the ridge taken off parallel to the plumb line. At hip and valley rafters, it amounts to one-half the 45° thickness of the hip or valley rafter taken parallel to the plumb line. In addition side cuts must be made for the jacks to fit flush against the hip or valley rafter. A bevel line should be marked back one-half the thickness of the jack rafter parallel to the allowance plumb line and a 45° side bevel cut parallel with the plumb line.

SUGGESTED READING FOR STUDENTS:

Modern Carpentry, Unit 9

Framing, Sheathing and Insulation, Unit 16

THE NEXT LESSON IS: VI-A-1(I)

INFORMATION SHEET
ON
ROOF FRAMING

V-D-2 (IS)

SUBJECT: Jack Rafter

INTRODUCTORY
INFORMATION:

Jack rafters are used in conjunction with hip and valley rafters to frame a hip or valley roof. Jack rafters are nothing more than common rafters that have been shortened and beveled to frame against, or between hip and valley rafters, rather than from the plate to the ridge board. There are four types of jack rafter. The type depends on its location and application (See Fig. 4). A hip jack rafter extends from a hip rafter to a rafter plate; a valley rafter extends from a valley rafter to a ridge board; a hip-valley cripple jack extends from a hip rafter to a valley rafter; and a valley-to-valley cripple jack extends between two valley rafters.

GENERAL INFORMATION:

Jack rafters have the same slope, or pitch as common rafters, therefore the same unit rise and run. This means that jack rafters have the same length per unit run (12") as common rafters. The unit length of a common rafter, remember, is the hypotenuse of a right triangle with the unit run as base and the unit rise as height. If a roof has a 7 in 12 slope, the unit length of both common rafter and jack rafter would be, according to Pythagorean's Theorem, the square root of ($7^2 + 12^2$), or 13.89". (See Fig. 1)

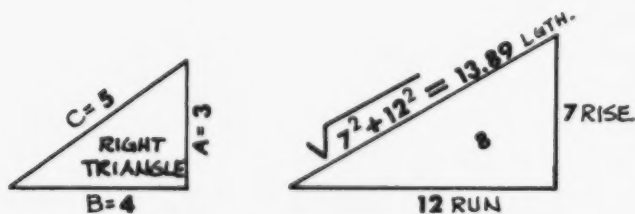


FIG. 1 PYTHAGOREAN'S THEOREM
 $A^2 + B^2 = C^2$

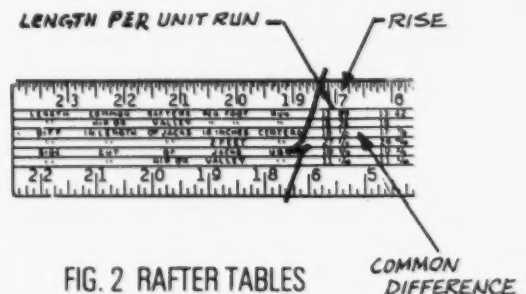


FIG. 2 RAFTER TABLES

This figure can also be looked up on the rafter table of a framing square by reading "length of common rafter per foot run" under the appropriate rise in inches, located on the body of the square. (See Fig. 2)

Now that the unit length has been established, the total length must be determined. The jacks are always on the same spacing as the common rafters. Common rafters are spaced either 16" or 24" O.C. Spacing has an important bearing on

the lengths of jack rafters since they are cut or interrupted by hip/valley rafters 45° to the spacing. The roof framing plan (Fig. 3) shows a hip roof with rafters spaced 16" O.C.

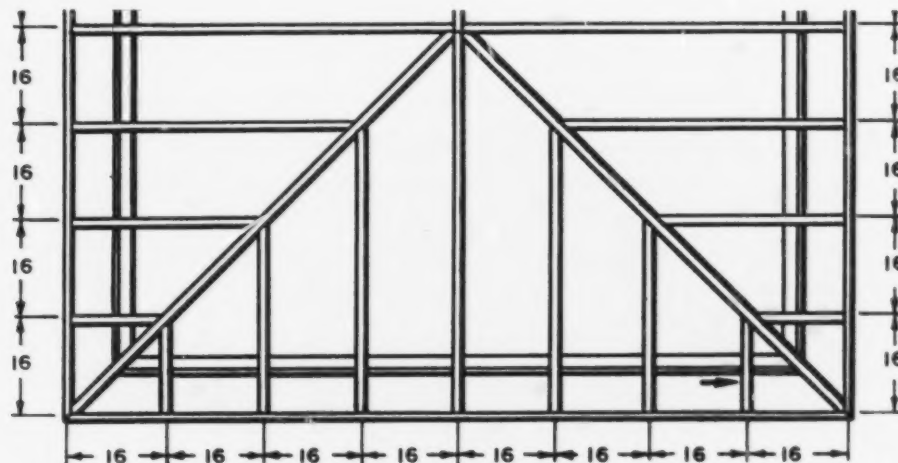


FIG. 3 HIP JACK FRAMING DIAGRAM

By observation we see that the rafter spacing is also the total run (theoretic) of the shortest jack rafter. The total run, 16", is 1.33 units of run ($16" \div 12"$). The rafter length then, would be the unit length (13.89") x no. of units (1.33) = 18.52", rounded equals 18 1/2".

This length is also the common difference in of these jacks. This means that the second shortest jack will be (2) x 18.52" long and the third shortest will be (3) x 18.52" long and so on. If the length of the common rafters is known the common difference may be subtracted to find the length of the longest hip jack, and again for each size smaller hip jack. The common difference of jack rafters can also be looked up on the rafter table of a framing square. Read "Difference in Length of Jacks 16" O.C., or 24" O.C.; under the appropriate rise in inches, located on the body of the square.

Let's review! So far, a-piece-of-cake! Jack rafters are shortened common rafters for framing into hip and/or valley rafters. To figure lengths you need to know rafter spacing and unit rise. Look up "common difference" on rafter table of framing square -- subtract from common rafter; add to shortest rafter.

However! This gives you the theoretic rafter length. As with common rafters, and hip and valley rafters; jack rafters must make allowance for the material thickness of the piece to which it is connecting as this has not been considered in calculating theoretic lengths.

This allowance is called a shortening allowance and may occur at one, or both ends. On hip jacks it occurs at the top end; on valley rafters, at the bottom end with a common rafter allowance at the top end to fit at the ridge; and on cripple jacks, at both ends (Fig. 4).

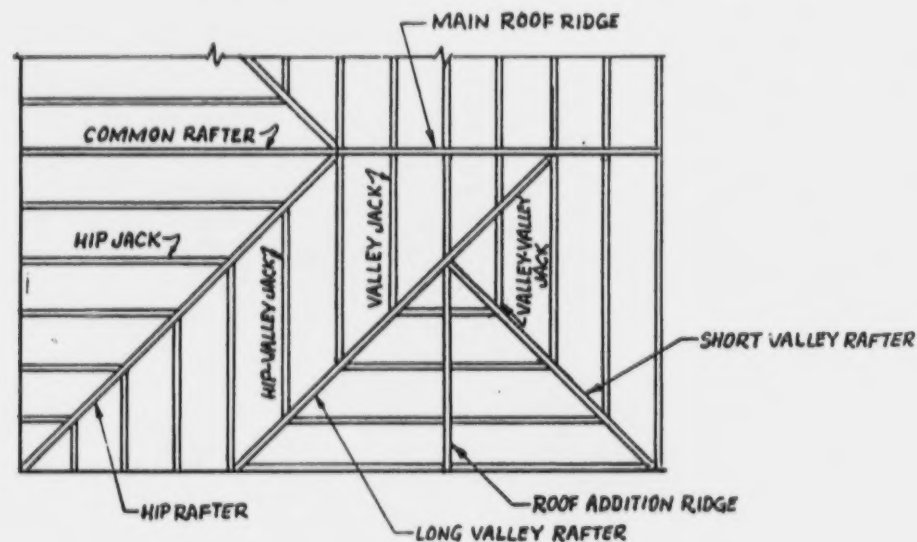


FIG. 4 PARTIAL ROOF FRAMING PLAN SHOWING DIFFERENT TYPES OF JACK RAFTER

The shortening allowance where a jack rafter fits into a hip or valley rafter is one-half the 45° thickness of the hip or valley rafter ($1 \frac{1}{16}$ " taken along the horizontal. (See Fig. 5)

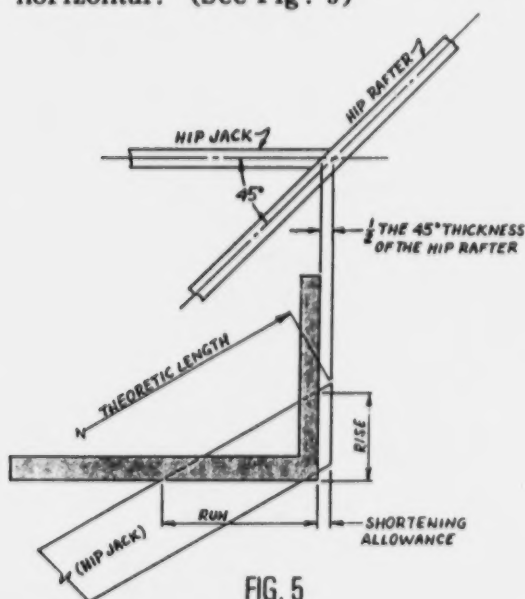


FIG. 5

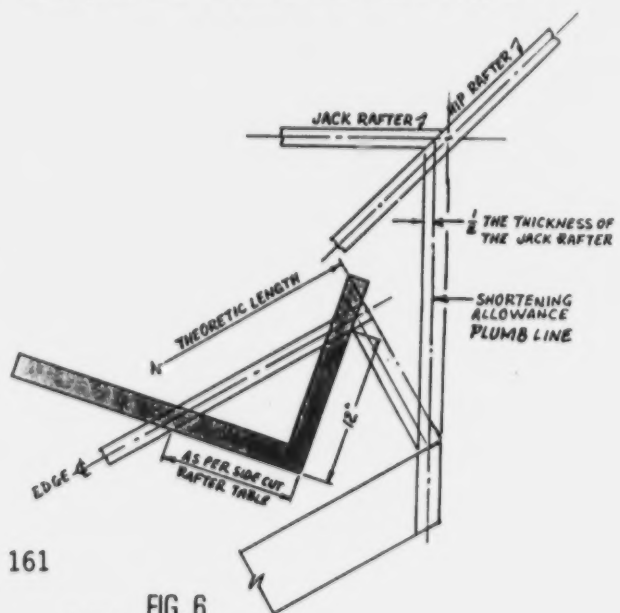


FIG. 6

In addition, all jack rafters must have a side cut to fit flush against a hip or valley rafter. Side cuts are made 45° to a plumb line through the shortening allowance. (See Fig. 6)

This layout can easily be performed using the framing square:

1. Square a line across the top of the rafter in line with the shortening allowance plumb line and draw an edge centerline to intersect
2. Look on rafter table of framing square under appropriate inch rise - read, "Side Cut of Jack, Use." Example" 7" rise, use 11 1/16"
3. Position framing square diagonally across the top of the rafter
 - a. With the tongue towards the end to be cut
 - b. With the elbow to the side to be cut
4. Using the outside edge of the framing square, align 12" dimension on tongue, and 11 1/16" dimension on body to same edge of rafter -- align edge of tongue to pass through intersection of lines (step #1)
5. Draw side cut on top of rafter

This can also be laid out by:

1. Measuring back one-half the rafter thickness - 3/4"
 - a. From the shortening allowance plumb line
 - b. Along the horizontal plane, and
 - c. Draw an edge bevel line (similar to drawing allowance plumb line)
2. Square line across the rafter top in line with both these lines - draw an edge centerline along the rafter top end
3. Connect points edge-at-bevel with center-at-allowance with straight-edge
4. Draw side cut on top of rafter

Now we have all the essentials for jack rafter layout - any kind of jack rafter; for the most complex looking roof. Keep in mind that jack rafters, in a specified roof, have several things in common. They have the same roof slope, therefore the same rise and run. They have the same spacing, common difference in lengths, same shortening allowance at a hip or valley, and the same side cut, although it may be to the opposite side or on the opposite end. Make, or study the roof plan. Break it down into components; organize your work! Make a master, or pattern rafter of like and/or similar rafters. (See Fig. 7). With a little practice, you will find that rafter layout, and framing is not difficult.

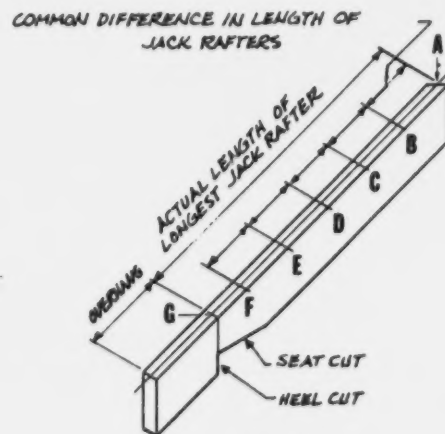


FIG. 7

Use the longest jack rafter as a pattern. The second jack rafter is BG, the third jack rafter is CG, and so on.

ASSIGNMENT SHEET
IN
ROOF FRAMING

V-D-2 (AS)
KEY

SUBJECT: Jack Rafters

AIM: The student will be able to identify the type, compare sizes, and calculate the lengths of various jack rafters.

INTRODUCTORY
INFORMATION:

At any time a carpenter should be able to look at the architect's prints and identify each type rafter. By studying a rafter plan or diagram, the carpenter should also be able to determine like rafters and rafters the same length. By using information provided on the prints the carpenter should be able to calculate lengths and make accurate rafter lay outs.

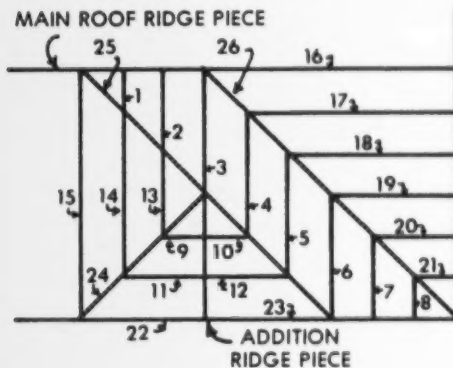
REFERENCES:

Information Sheet V-D-2 (IS), "Jack Rafters"
Modern Carpentry, Unit 16

QUESTIONS OR PROBLEMS:

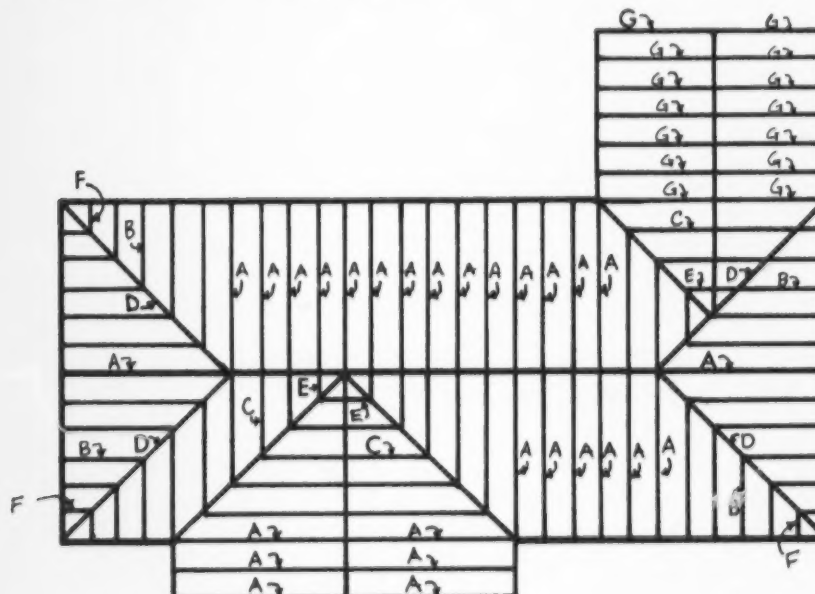
1. What is the unit length of hip jack rafters on 1/3 pitch? 14.42" or 14 7/16"
2. What is the unit length of valley jack rafters on a 7 in 12 slope? 13.89" or 13 7/8"
3. What is the unit length of a valley to valley cripple jack on 1/4 pitch? 13.42" or 13 7/16"
4. What is the common difference of the hip jacks in problem #1 if the rafters are spaced 16" O.C.? 19.22" or 19 3/16"
5. What is the common difference of the valley jacks in problem #2 if the rafters are spaced 24" O.C.? 27.78" or 27 1/2"
6. A hip roof 16'-0 wide has a 1/3 pitch. What are the lengths of its hip jacks if the rafters are spaced 16" O.C.?
19.22" or 19 3/16", 38.44" or 38 7/16", 57.66" or 57 11/16", 76.89" or 76 7/8", 96.11" or 96 1/8"

7. Different rafters with like lengths frequently appear in the same roof frame. A prime example of this would be a hip rafter and a valley rafter extending from a common rafter plate to the same ridge board. Below is a partial roof frame plan with the framing members numbered. Match the members with duplicate lengths.



- #1 8, 9, 10, 21
#2 7, 11, 12, 20, 13
#3 4, 5, 6, 19, 22, 23
#14 18
#15 16
#25 26

8. Like rafters frequently appear in different parts (areas) of a roof frame. The roof frame plan below has labeled certain frame members with a letter. Label all other like members in the plan with the same letter.
NOTE: Pay close attention to side cuts.



INSTRUCTOR'S PLAN
MANIPULATIVE LESSON

V-D-2(S)

- TASK: Lay Out And Cut Hip And Valley Jack Rafters
- AIM: The student will be able to lay out and cut hip and valley jack rafter, using a framing square and step-off method of lay out, according to dimensions provided on architectural prints.
- TOOLS AND EQUIPMENT: Framing square, marking pen or pencil, portable circular power saw (6½" min.)
- MATERIALS: 2" framing lumber, size and type as per plans and specifications
- TEACHING AIDS: V-D-2 Job and Task Sheets
- REFERENCES: Information Sheet V-D-2(IS)
Blueprints and Specifications
- PREREQUISITE EXPERIENCE OF THE LEARNER: The student must have successfully completed previous lessons V-B-1(I), V-B-1(S), and V-D-1(I); all previous safety lessons and continue to display a sincere interest in learning the building trades.
- CHECKING STANDARDS:
1. Rafter length calculations.
 2. Rafter material selection.
 3. Accuracy of rafter lay out.
 4. Rafter placement and fit.

I. PREPARATION (OF THE LEARNER - MOTIVATION)

Jack rafters are used in framing hip, or hip and valley roofs. Jack rafters are often said to be common rafters forshortened by the intersection of hip or valley rafters. Jack rafters have the same slope or pitch as common rafters, and are equally spaced with, and parallel to common rafters.

This means that in an equal-pitch framing situation, the unit rise of a jack rafter is always the same as the unit rise of a common rafter; a hip jack has the same bird's-mouth (seat cut) as a common rafter; and a valley jack rafter has the same ridge allowance and plumb cut as a common rafter; and that jack rafter lengths are based on equal spacing and a common difference. The bevel or side cuts are the same but must be laid out and cut properly.

Keep these facts in mind and they will tend to simplify jack rafter lay out.

II. PRESENTATION (OF THE SKILLS)

STEPS	KEY POINTS (THINGS TO REMEMBER TO DO OR SAY)
1. Study Plans/ Specifications	1. Become familiar with rafter requirements

2. Calculate Common Rafter Length (Theoretic)
 2. Determine material type, grade, size
 3. Obtain key dimensions
 - a. Rise, run, span
 - b. Slope and/or pitch
 - c. Rafter spacing
3. Determine Common Difference
 1. Verify rafter spacing - 16" or 24"
 2. Read "difference in length of jack rafters"
 - a. On body of framing square
 - b. Below "inch number" equal to rise in inches
 - c. According to rafter spacing
4. Establish Jack Rafter Lengths
 1. In a series
 2. According to rafter type
 3. According to rafter's position in the roof frame
 4. Subtract; add common difference to obtain lengths
 5. Record results for rafter lay out
5. Lay Out Jack Rafter Lengths (Theoretic)
 1. For a series of jack rafters
 2. Use common rafter for lay out
 - a. After common rafter is laid out
 - b. Before common rafter is cut
 3. Square line across rafter top edge aligned with ridge center plumb line
 4. Scribe material thickness centerline along rafter top edge
 5. Measure "common differences"
 - a. Equally spaced
 - b. Along material thickness centerline
 - c. From line squared at ridge plumb line
 6. Mark points measured with lines squared across the rafter top edge

Note: These points mark the theoretic lengths of a series of jack rafters. Also, the difference in these points will yield the theoretic length of every jack rafter in a roof frame; depending on their location and type.

7. Check lengths as established; (step #4)
 - a. Mark line square across rafter top edge at building plumb line
 - b. Measure jack rafter lengths from building plumb line to appropriate common difference
 8. Cut common rafter to size - use as pattern rafter for jack rafter lay out
-
6. Lay Out Jack Rafter Length
 1. One-at-a-time
 2. Use common rafter with theoretic lengths laid out as a pattern (refer to step #5)
 3. Select material
 - a. Type, grade, size as per specifications
 - b. Lengths as per common rafter laid out
 - c. Pick and choose to prevent waste
 4. Position pattern rafter
 - a. Flat on rafter pattern
 - b. Flush with top; bottom edges
 - c. Positioned in proper relation for that rafter's length

Examples:

 - * Hip jack - flush with bottom end of pattern rafter
 - * Valley jack - flush with top end of pattern rafter
 - * Hip/valley jack - extend beyond marks on top of rafter pattern for appropriate location and length
 6. Mark tail, bird's-mouth, plumb cut that are common with common rafter
 - a. Flush with common rafter pattern
 - b. While holding flush with pattern rafter
 7. Mark line(s) squared across top edge
 - a. Aligned with squared lines on pattern
 - b. For appropriate length (theoretic)
 7. Lay Out Shortening Allowance
 1. Use framing square and straightedge
 - a. Clamped diagonally across face of square
 - b. Set to rise and run as in common rafter lay out
 2. Position straightedge and framing square on rafter
 - a. Straightedge along rafter top
 - b. Elbow of square across rafter face
 - c. Outside of tongue aligned to mark squared (theoretic length) across top of rafter

3. Mark theoretic length plumb line outside of tongue
4. Measure shortening allowance (1 1/16")
 - a. Along body of framing square (level)
 - b. From "plumb line mark" of theoretic length (key point #3 above)
 - c. In direction rafter must be shortened

Examples:

- * Toward rafter tail - hip jack
- * Toward rafter plumb cut- valley jack
- * Toward rafter center - hip/valley jack
- d. Mark point measured on face of rafter

5. Mark shortening allowance
 - a. With plumb line at point marked
 - b. With line squared across rafter top in line with plumb line

8. Lay Out Side Cut(s)

1. Scribe center line
 - a. Of rafter material thickness
 - b. From "shortening allowance line" squared across rafter top
 - c. Approximately 2'-0 long along rafter top edge
2. Read "Side Cut of Jacks Use"
 - a. On rafter table of framing square
 - b. Under "inches" equal to rise in inches
3. Position framing square
 - a. Flat on top of the rafter
 - b. With tongue in direction of side cut
 - c. With 12" dimension, outside of tongue on intersection of centerline at squared line
 - d. With dimension read, outside of body on centerline at opposite end
4. Mark side cut
 - a. On top of rafter material
 - b. Outside of framing square tongue
5. Mark plumb lines each side
 - a. Aligned with side cut
 - b. Use straightedge clamped to framing square as lay out of other plumb lines

9. Check Saw Dimensions

1. On 2" x 6" short approx. 3'-0 lq.
 - a. Scribe edge centerline
 - b. Mark line square across face
 - c. Approx. 8" from one end
2. Set hand screw clamp
 - a. Flush to squared line
 - b. With 8" end of 2" x 6" exposed
3. Adjust portable circular power saw

- a. To make 45° cut
 - b. Follow all safety rules - unplug saw
 4. Make double side cuts 45°
 - a. Use clamp as guide for saw base
 - b. Follow operator safety - keep guide on operators left, turn 2" x 6" over for second cut
 5. Verify:
 - a. Saw cuts intersect at center of material thickness
 - b. Dimension from intersection of saw cuts to edge of clamp (guide line)
10. Make Side Cut(s)
1. Measure "dimension verified"
 - a. On the face of the rafter
 - b. From the shortening allowance plumb line
 - c. Square with the plumb line
 - d. In direction of rafter body
- Note: Use framing square and straightedge similar to rafter length lay out
2. Mark guide line
 - a. Through point measured
 - b. Parallel to plumb line
 3. Set hand screw clamp
 - a. Square to line
 - b. Opposite side from plumb line
 4. Make side cut 45°
 - a. Direction and side as per lay out
 - b. Use clamp as guide for saw base
 - c. Practice all operator safety in use of portable circular power saw

III. APPLICATION (PRACTICE BY LEARNER UNDER CLOSE SUPERVISION)

Instructor: Demonstrate steps of jack rafter lay out
Stress key points during lesson presentation
Pass out Job and Task sheets

Student: Practice job and tasks under close supervision

IV. VERIFICATION AND/OR EVALUATION (CHECK ON STUDENT'S ABILITY)

Performance Test!

Student(s) to lay out and cut jack rafters as per builders plans and specifications.

V. SUMMARY (TELL THE STEPS ON PROCEDURE AS TO WHAT, HOW, AND WHY. REVIEW CHECKING STANDARDS. THIS SUMMARY MAY BE GIVEN AT ANY PLACE IN THE LESSON THE TEACHER FEELS WILL BE PROFITABLE TO THE STUDENTS)

Jack rafters are used in framing hip, or hip and valley roofs. Jack rafters are the same as common rafters except they have been forshortened by the intersection of a hip or valley rafter - or both. They are parallel to common rafter. In addition, hip jacks have the same bird's-mouth and rafter tail as common rafters, and valley jacks have the same ridge plumb cut as common rafters.

The difference in jack rafters is in their lengths and the side cuts where they make-up to the hip and/or valley rafters. Since jacks are intersected at a 45° angle by hip and valley rafters, the difference in the run of jack rafters is equal to the spacing of jack rafters; and since jack rafters have the same "length per unit run" as common rafters, the "common difference" in jack rafter lengths can be calculated by multiplying the unit length of the common rafter "x" the spacing in units of run. This common difference in lengths of jack rafters can be laid out along the top edge of a common rafter and used as a pattern for all jack rafter lay out.

To lay out a jack rafter:

1. Position rafter material on rafter pattern in relation to its position (lengthwise) with common rafter in roof frame.
2. Transfer all available lay out lines - rafter tail, bird's-mouth theoretic length, and or ridge plumb cut - to rafter.
3. Lay out shortening allowance (one-half the 45° thickness of hip or valley rafter) along horizontal (level) line from plumb line of theoretic rafter length - transfer point measured to rafter top center via plumb line and line squared across top. Mark point!
4. Place framing square flat on rafter top with tongue in direction of side cuts. Read "Side Cut of Jacks Use" under "inches rise" on rafter table of square. Position "dimension read" on body of square flush at rafter top edge; position 12" dimension on tongue at rafter same edge; slide square so edge of tongue passes through point "shortening allowance", on rafter top. Mark "side cut" through point at edge of tongue.

SUGGESTED READING FOR STUDENTS:

Modern Carpentry, Unit 9
Guide To Residential Construction, Unit 19

THE NEXT LESSON IS: VI-A-1(S)

JOB SHEET
ON
ROOF FRAMING

V-D-2(J)

NAME OF JOB: Lay Out And Cut Jack Rafters

DRAWINGS: Architects floor plan, roof framing plan, sections and details

MATERIALS: 2" framing lumber as per plans and specifications

TOOLS AND EQUIPMENT: 25' Steel measuring tape, straightedge clamp, framing square, marking pen or pencil, portable circular power saw, cross-cut saw, hand-screw clamp, marking gage.

GENERAL INSTRUCTIONS: Study the architects plans and details. Become familiar with the roof framing requirements and dimensions. Plan your work! Make all measurements and marks accurately. Double check lay outs. Practice tool and operator safety in the use of power tools and equipment.

PROCEDURES AND/OR TASKS: V-D-2(TS), Make Jack Rafter Pattern
V-D-2a(TS), Lay Out Hip Jacks
V-D-2b(TS), Lay Out Valley Jacks
V-D-2c(TS), Lay Out Cripple Jacks
V-D-2d(TS), Cut Jack Rafters

CHECK POINTS: Material Selection
Common Difference of Jacks
Rafter Lengths
Accuracy of Lay Out
Direction of Side Cuts
Tool Safety

TASK SHEET
IN
ROOF FRAMING

V-D-2(TS)

TASK Make Jack Rafter Pattern

JOB: Roof Framing

TRADE: Building Trades

TOOLS AND MATERIALS: Framing square, marking pen or pencil, 25' steel tape measure, portable circular power saw, 2" framing lumber as per plans and specifications

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Study Plans; Specifications	1. Become familiar with roof framing requirements 2. Determine material type, grade, size 3. Obtain key rafter dimensions: a. Rise, run b. Slope or pitch c. Rafter spacing
2. Lay Out Common Rafter	1. As per lesson V-B-1(S) 2. Very accurately! a. Calculate rafter length b. Select material c. Step-off rafter length with framing square d. Mark ridge center and plumb cut lines e. Mark bird's-mouth and rafter tail f. Check rafter lay out for accuracy
3. Determine Common Difference	1. Of jack rafter lengths 2. Verify rafter spacing (16" or 24") 3. Read "Difference In Length of Jacks" a. On rafter table of framing square b. Under "inch number" equal to rise in inches c. According to rafter spacing
4. Lay Out Common Difference	1. Along top of common rafter a. From line squared across top b. At ridge center plumb line 2. Measure common differences a. Very accurately b. Equally spaced 3. Mark common differences a. With lines squared across rafter top b. At points measured (above)

5. Cut Rafter To Size

1. Use portable circular power saw
2. As per lesson V-B-1(S)
3. Cut very accurately:
 - a. Ridge plumb cut
 - b. Bird's-mouth
 - c. Rafter tail
4. Practice all safety in operator use and handling of portable power saw

TASK SHEET
IN
ROOF FRAMING

V-D-2a(TS)

TASK: Lay Out Hip Jacks

JOB: Roof Framing

TRADE: Building Trades

TOOLS AND MATERIALS: Framing square, marking pen or pencil, marking gage, 2" framing lumber as per plans and specifications.

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Study Plans And Specification	- Become familiar with roof frame - Location, number of hip jacks - Same, similar hip jacks - Determine material type, grade, size
2. Select Rafter Material	- Type, grade material as per specifications - Lengths as per: - Location; spacing in roof frame - Number as per same, similar rafter - Pick and choose to prevent waste
3. Position Pattern Rafter	- Flat on saw horses; other surface - Convenient for lay out
4. Position Rafter Material	- One-at-a-time - Flat on rafter pattern - Flush at top, bottom edges - Flush at bottom end (rafter tail)
5. Transcribe Marks	- To rafter material face - At rafter tail plumb cut - At rafter bird's-mouth - While holding material flush with pattern - Mark lines sharp and square
6. Transfer Length (Theoretic)	- To rafter material top - With line square across top of material - Align with appropriate length on pattern <u>Note:</u> Set pattern rafter aside!
7. Lay Out Shortening Allowance	- Set cut of the rafter (rise and run) - On the framing square - With straightedge clamp

- c. As in common rafter lay out
 - 2. Position straightedge and framing square
 - a. Straightedge along rafter top edge
 - b. Elbow of square flat across rafter face
 - c. Outside of tongue aligned with rafter length
 - 3. Mark theoretic length plumb line
 - a. On face of rafter
 - b. Outside of tongue
 - 4. Measure one-half the 45° thickness of the hip rafter (1 1/16" on 2" stock)
 - a. Along outside of body
 - b. From elbow of square
 - c. Mark point measured
 - 5. Mark shortening allowance
 - a. With plumb line at point marked
 - b. With line squared across rafter top
8. Lay Out Side Cut
- 1. Scribe material thickness centerline
 - a. Approximately 2"-0 long
 - b. Along rafter top
 - c. From rafter top end
 - 2. Read "Side Cut of Jacks Use"
 - a. On rafter table of framing square
 - b. Under inch number equal "rise in inches"
 - 3. Position framing square
 - a. Flat on top of rafter
 - b. With tongue in direction of side cut
 - c. With 12" mark, outside of tongue, on intersection of centerline (scribed) and squared line of shortening allowance
 - d. With dimension read, outside of body on centerline opposite end
 - 4. Mark side cut
 - a. On top of rafter
 - b. Outside of framing square tongue

TASK SHEET
ON
ROOF FRAMING

V-D-2b(TS)

TASK: Lay Out Valley Jacks

JOB: Roof Framing

TRADE: Building Trades

TOOLS AND MATERIALS: Framing square, marking pen or pencil, marking gage, 2" framing lumber as per plans and specifications

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Study Plans And Specifications	1. Become familiar with roof frame requirements a. Location of valley jacks b. Lengths of valley jacks according to location; spacing 2. Determine material requirements a. Type, grade b. Size, length
2. Select Rafter Material	1. Type and size as per plans, specifications 2. Lengths as per marks on pattern rafter a. According to rafter location b. According to rafter spacing
3. Position Pattern Rafter	1. Flat on saw horses, other surface 2. Convenient for lay out
4. Position Rafter Material	1. Flat on pattern rafter 2. At top end of pattern rafter 3. Flush with rafter top, bottom edges
5. Transfer Marks And/Or Cuts	1. From pattern rafter to rafter material a. At plumb cut line on face of rafter b. At rafter length on top of rafter 2. While holding material flush with pattern 3. Mark lines sharp and clear, flush and/or aligned with pattern
6. Lay Out Shortening Allowance	1. On rafter material 2. Use framing square and straightedge a. Clamp to "cut of the rafter" (rise and run) b. As in step-off rafter lengths
A. Position Straightedge And Framing Square	1. On rafter top edge 2. With elbow of square flat across rafter face

3. With tongue of elbow aligned to rafter length mark on top
- B. Mark Plumb Line
 1. Of thoeretic length
 2. On rafter face
 3. At tongue aligned with length marked on top
- C. Measure Allowance
 1. Slide straightedge and framing square
 - a. Along rafter length
 - b. In direction "from bottom to top" of rafter
 2. Align 1 1/16" dimension (one-half the 45° thickness of 2" valley rafter)
 - a. Inside framing square body (level)
 - b. With theoretic length plumb line
- D. Mark Shortening Allowance
 1. With plumb line inside of tongue
 2. With line squared across rafter top
7. Lay Out Side Cut
 1. Scribe material centerline
 - a. Approximately 2'-0 long
 - b. From rafter length marked square
 - c. Along rafter rop edge
 2. Read "Side Cut of Jacks Use"
 - a. On rafter table of framing square
 - b. Under inch number equal to "rise in inches"
- A. Position Framing Square
 1. Flat across top of rafter
 2. With tongue in direction of side cut
 3. With 12" dimension, outside of tongue, on intersection of centerline (scribed) and line squared (shortening allowance)
 4. With "dimension read," outside of body, on centerline opposite end
- B. Mark Side Cut
 1. On top of rafter
 2. Outside of framing square tongue

TASK SHEET
ON
ROOF FRAMING

V-D-2c(TS)

TASK: Lay Out Cripple Jacks

JOB: Roof Framing

TRADE: Building Trades

TOOLS AND MATERIALS: Framing square, marking pen or pencil, marking gage, 2" framing lumber as per plans and specifications

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Study Plans And Specifications	- Become familiar with roof frame - Location of cripple jacks - Types of cripple jack - Lengths according to location; spacing - Quantities according to lengths, spacing - Determine material type, grade, size
2. Select Rafter Material	- Type, grade, size as per specifications - Lengths as per marks on pattern rafter - According to rafter location - According to rafter spacing - Pick and choose to prevent waste
3. Position Pattern Rafter	- Flat on saw horses, other surface - Convenient for lay out
4. Position Rafter Material	- Flat on pattern rafter - Flush at top and bottom edges - Between marks on pattern rafter for appropriate length * Ends of material extend beyond length sufficient for plumb and side cuts
Check Points:	
5. Transfer Length (Theoretic)	- From pattern rafter to rafter material - With lines marked square - Across top of material - Aligned with appropriate length marks on pattern - While holding material in place flush with pattern
6. Lay Out Shortening Allowance(s)	- One end-at-a-time - Use framing square with straightedge - Clamped diagonally across rafter face - Set to rafter rise and run

3. Similar to step-off method of common rafter lay out
- A. Position Framing Square And Straightedge
 1. Straightedge along rafter top edge
 2. Elbow of square across face of rafter
 3. Edge of tongue aligned with "length mark" on top of rafter
- B. Mark Plumb Line
 1. Of theoretic length
 2. On face of rafter
 3. At edge of tongue aligned with mark
- C. Measure Allowance
 1. One-half the 45° thickness of hip or valley rafter (1 1/16 on 2" stock)
 - a. From "theoretic length" plumb line
 - b. In direction to shorten rafter
 2. Along body of square (level line)

Note: Slide straightedge along rafter top edge to adjust framing square as necessary
- D. Mark Allowance
 1. With plumb line, at point measured
 2. With line squared across top
7. Lay Out Sid Cut(s)
 1. One-at-a-time
 2. Read "Side Cut of Jacks Use"
 - a. On rafter table of framing square
 - b. Under inch number equal to rise in inches
 3. Scribe material centerline each end
 - a. Approximately 2'-0 lg.
 - b. Along rafter top edge
- A. Position Framing Square
 1. Flat across rafter top
 2. With tongue in proper direction of side cut
 3. With 12" dimension, outside of tongue on intersection of centerline (scribed) and squared line (shortening allowance)
 4. With "dimension read", outside of body on centerline opposite end
- B. Mark Side Cut
 1. Outside of framing square tongue
 2. On top of rafter
 3. To pass through center point of shortening allowance

TASK SHEET
ON
ROOF FRAMING

V-D-2d(TS)

TASK: Cut Jack Rafters

JOB: Roof Framing

TRADE: Building Trades

TOOLS AND MATERIALS: Framing square, marking pen or pencil, hand screw clamp, circular portable power saw (6 1/2" min.) with combination blade, cross-cut saw, 2" framing lumber laid out for jack rafters

TASK BREAKDOWN:

STEPS	KEY POINTS
1. Position Rafter Material	1. Flat on saw horses, other surface 2. Convenient for cutting (sawing)
2. Check And Adjust Power Saw	1. For operating condition a. Guards, covers in place; operational b. Adjustment mechanisms functional c. Blade properly installed, sharp d. Electrical cord condition good, sufficient length, properly grounded 2. Practice all operator safety in handling and inspection 3. Adjust blade square with saw base 4. Adjust blade for depth of cut
3. Cut Rafter Material	1. One-at-a-time a. At rafter tail and bird's-mouth b. At rafter plumb cut 2. Practice all operator safety in use of portable power saw a. Support rafter material b. Keep saw base flat on rafter material c. Use saw guide to feed sawcuts straight and smooth d. Keep extension cord, other object free of saw path
4. Check Saw Dimensions	1. On a 2" x 6" short (approx. 3'-0" long) a. Scribe edge centerline b. Mark line square across face approx. 8" from one end 2. Set hand screw clamp a. Flush to squared line b. With 8" end exposed

3. Adjust portable circular power saw
 - a. To make 45° cut
 - b. Follow all safety, unplug saw
4. Make double side cuts 45°
 - a. Use clamp as guide for saw base
 - b. Practice operator safety - keep guide on operator's left, turn 2" x 6" over for second cut
5. Verify:
 - a. Saw cuts intersect at centerline of material thickness
 - b. Dimension from intersection of saw cuts to edge of clamp (guide line)

5. Make Side Cut(s)

1. Measure "dimension verified"
 - a. On face of rafter
 - b. From shortening allowance plumb line
 - c. Square with plumb line
 - d. In direction of rafter body
 - e. Use framing square and straightedge similar as in rafter lay out
2. Mark guide line
 - a. Through point measured
 - b. Parallel to plumb line
3. Set hand screw clamp
 - a. To guide line flush
 - b. Body of clamp opposite side from plumb line
4. Make side cut
 - a. Direction and side as per lay out
 - b. Use clamp as guide for saw base